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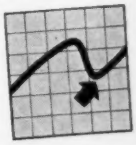

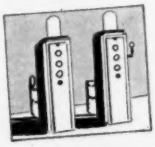

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Vol. 36 June 1944 No. 6

Employee Progress Rating and Personnel Records

By Philip B. Niles

IN the April JOURNAL the author presented a Salary Administration Plan, together with the Job Classifications and Job Descriptions which have been adopted for the operating companies in the American Water Works and Electric Company system. This paper is a discussion of the methods followed in initiating and approving payroll changes under this system.

Although publicly-owned water works are removed from the regulations of wage and salary stabilization, certain of the procedures which must be followed in order to maintain orderly payroll administration and adequate personnel records should be of interest to executives and supervisors in the municipally-owned group from the standpoint of personnel.

Payroll Changes

As is generally known, the penalty to a private employer for making an illegal wage or salary change may be the elimination of the entire salary or wage of the individual receiving the adjustment from the operating expenses of the employer for the period during which the change in salary was in effect. With federal taxes at their present level, this is a penalty not to be taken lightly. Furthermore, the responsibility for stabilization of wages and salaries is split between two federal agencies namely, the War Labor Board and the Department of Internal Revenue Salary Stabilization Unit. To make a somewhat complicated picture more complicated, these two agencies do not apply the same rules in their regulatory procedures.

For the purposes of this article, therefore, stabilization is discussed wherever possible from the standpoint of the combined regulations. The War Labor Board rules or those of the Salary Stabilization Unit will only be discussed specifically when the divergence in regulatory principles is such as to make it necessary from the standpoint of clarity.

It is well to remember that regulations covering the upward adjustments in wages or salaries are most strict; furthermore, that individual wages or salaries below the level of $5,000 a year cannot be decreased without ap-

A contribution by Philip B. Niles, Director, Customer and Employee Relations, American Water Works and Elec. Co., New York, N.Y.

proval. Consequently, every pay change, whether it be an increase or decrease, must be considered in respect to pertinent stabilization regulations.

There are two other types of payroll changes which must be considered from the standpoint of an additional federal regulatory agency—those that involve hirings and separations which are covered by the regulations of the War Manpower Commission.

In any organization which has an appreciable number of employees and a substantial turnover—and most organizations have under war conditions—it is important, even vital, to be sure that every payroll change is legal in regard to the various regulations involved. Moreover, every responsible executive, municipal or private, should desire to know that payroll changes are soundly made from the standpoint of ordinary business efficiency.

To meet these requirements our company has devised a form entitled "Recommendation for Change in Payroll" (Form W–358)* which, in respect to every type of payroll change, reveals the necessary information with regard to the pertinent federal regulations. It will be noted that there are six general types of payroll changes. In the interest of brevity, consider the method by which a merit increase is actuated by a department head for one of the members of his staff. Reference to IV, "Merit Increases," on the form discloses that there are eight questions asked. It will readily be seen that the answers to these questions will indicate whether or not the salary or wage change meets the regulatory requirements of stabilization.

If the company operates under General Order 31 of the War Labor Board, covering the wages and salaries of employees within that agency's jurisdiction, it needs to know that a merit increase does not exceed in any one year two-thirds of the difference between the minimum and the maximum of the range for the appropriate classification, or 10¢ an hour, whichever is the greater. Also, the executive approving a merit increase from the standpoint of stabilization must know when the last pay change was made, the minimum and maximum of the classification and other pertinent information. This information is disclosed in the fourth box on the form reproduced here.

Promotions or reclassifications must meet a different standard under wage and salary stabilization and an appropriate box is included in the form for such payroll changes.

It will be further noted that on additions to and separations from the payroll, questions regarding "Certificates of Availability" are included in order that the approving executive may be sure that these changes conform with the War Manpower Commission regulations.

The rest of this form is largely self-explanatory, but it is believed that, complicated as it may seem, the information contained thereon is necessary in order that an employer may have the necessary records to prove that all payroll changes have been made in accordance with the applicable regulations. Furthermore, much of this information is useful from the standpoint of normal salary administration, regardless of the present wartime restrictions of stabilization.

* All forms referred to in this paper will be found on pages 607–614 herein.

In a large company, with many payroll changes covering employees within the jurisdiction of the War Labor Board, the employer is not permitted to award length-of-service and merit increases at his own discretion. The employer's actions are strictly controlled by General Order 31, as further explained in Interpretative Bulletin No. 2, following the same order. In fact, these regulations set up an annual budget for merit and length-of-service increases. This budget is arrived at by multiplying the number of employees by 5¢ (presumably 5 cents an hour). From this total are subtracted all merit and length-of-service increases computed in cents per hour. To this total is added 5¢ for each new employee who may be hired and 5¢ is subtracted for each employee who may be dropped from the payroll. This budget controls for a 12-mo. period, usually commencing July 1 and terminating June 30. Bona fide promotions are not charged against the budget.

It can be readily seen that Form W–358 makes it possible to compute easily and quickly the number of length-of-service and merit increases chargeable against this budget. It also permits the adjustment of the budget as separations from the payroll are made or as additional personnel is hired.

Progress Rating

The Water Works Division of the American Water Works and Electric Company has recently adopted a plan of progress rating which is similar in form to the conventional merit rating procedure long in use by many industrial employers. Progress rating permits the executive to review the individual employee's progress in the organization so that when consideration is given to a merit increase for such employee there is ample evidence in the personnel file that the individual has earned the salary or wage adjustment recommended. The form adopted by this company is reproduced here as Form W–88. Little comment is necessary as the procedure is one which is generally familiar to executives interested in personnel work.

The last page of this form, however, does serve a somewhat novel purpose. Note that this page provides for a summary of the rating information and develops data as to individual changes which may affect the employee's being rated in regard to his family, activity in the community and other data. This information is used to keep up to date the basic personnel file of each employee, such information being posted on an Employment Record form to be described later. Progress rating of each employee is checked once a year by a committee of each individual employee's supervisors. The average point ratings for all employees are computed and exceptional progress is noted and can be speedily rewarded through permissible merit increases or available promotions.

It should be emphasized that besides revealing merit, the progress rating procedure also reveals shortcomings. Through the use of this personnel tool it is possible to help individual employees overcome shortcomings and thus fit them to become better workers and assist them in their climb up the ladder of responsibility.

Basic Personnel Records

Reference has been made to the Employment Record and Personnel Record form, reproduced here as Form W–79–43197. The Employment Rec-

ord side of the form is completed at the time of employment. The Personnel Record side of the form is kept up to date by posting from the payroll change form and from the last page of the Progress Rating form.

It is believed that the combined Employment and Personnel Record form permits management to have available at all times up-to-date and useful personnel information regarding every employee. It is a form which is permanent in character and from which the supervisor or executive may obtain all important information to aid in solving the many personnel problems which are now so important a part of the day-to-day operation of any business enterprise.

It is not expected that the casual reader will be able to devise a complete and workable personnel program from a perusal of this article. However, a careful study of the forms reproduced herewith will indicate the general purposes, value or applicability of the procedures described. The author will be happy to expand upon any particular matter in connection with this presentation through individual correspondence with any fellow member of the water works profession.

FORM W 358

RECOMMENDATION FOR CHANGE IN PAYROLL

COMPANY _____ DATE _____

EMPLOYEES NAME _____ SOCIAL SECURITY ACCOUNT NUMBER _____

DEPARTMENT _____ DATE OF EMPLOYMENT _____

I. NEW EMPLOYEE

If this recommendation covers the hiring of a new employee, please answer the following questions:-

1. RATE OF PAY $_____ PER _____
2. PROPOSED JOB CLASSIFICATION _____ (Standard AWWaE Co.)
3. RANGE OF SUCH CLASSIFICATION _____
4. DATE SALARY TO COMMENCE _____
5. DOES THIS EMPLOYMENT: (Check one) ____INCREASE TOTAL NUMBER OF EMPLOYEES ____REPLACE FORMER EMPLOYEE
6. DID EMPLOYEE PRESENT "CERTIFICATE OF AVAILABILITY" ____YES ____NO IF NOT WHY NOT _____

II. LENGTH OF SERVICE INCREASE

If this recommendation involves a length of service increase, please answer the following questions:-

1. RATE OF PAY AT EMPLOYMENT $_____ PER _____
2. PRESENT RATE OF PAY $_____ PER _____
3. RECOMMENDED RATE OF PAY $_____ PER _____
4. RATE OF PAY TO CHANGE WITH PAYROLL BEGINNING _____
5. IF A PREVIOUS "LENGTH OF SERVICE INCREASE" HAS BEEN GRANTED TO THIS EMPLOYEE WHAT WAS THE DATE THEREOF _____ AMOUNT $_____ PER _____
6. PRESENT JOB CLASSIFICATION _____ (Standard AWWaE Co.)
7. RANGE OF SUCH CLASSIFICATION _____

III. PAYROLL CHANGE APPROVED BY FEDERAL AGENCY

If this recommendation involves a payroll change approved by a Federal Agency, please answer the following questions:-

1. PRESENT RATE OF PAY $_____ PER _____
2. APPROVED RATE OF PAY $_____ PER _____
3. RATE OF PAY TO CHANGE WITH PAYROLL BEGINNING _____
4. WAS THIS CHANGE MADE AS RESULT OF APPROVAL BY:- ____NATIONAL WAR LABOR BOARD ____REGIONAL WAR LABOR BOARD ____REGIONAL STABILIZATION UNIT U.S. TREASURY DEPARTMENT
5. GIVE IDENTIFICATION OF FEDERAL ORDER OF APPROVAL (docket number or ruling): _____
6. PRESENT JOB CLASSIFICATION _____ (Standard AWWaE Co.)
7. RANGE OF SUCH CLASSIFICATION _____
8. IF FEDERAL RULING INCREASED MAXIMUM OF EXISTING RANGE, STATE SUCH NEW RANGE _____

IV. MERIT INCREASES

If this recommendation involves a merit increase please answer the following questions:-

1. PRESENT RATE OF PAY $_____ PER _____ 2. RECOMMENDED RATE OF PAY $_____ PER _____
3. RATE OF PAY TO CHANGE WITH PAYROLL BEGINNING _____ 4. DATE OF LAST PAYROLL CHANGE _____
5. REASON FOR LAST CHANGE: (Check one) ____LENGTH OF SERVICE INCREASE ____MERIT INCREASE ____RECLASSIFICATION ____PROMOTION
6. AMOUNT OF LAST WAGE OR SALARY CHANGE $_____ PER _____ 7. PRESENT JOB CLASSIFICATION _____ (Standard AWWA&E Co.)
8. RANGE OF SUCH CLASSIFICATION _____

V. PROMOTIONS OR RECLASSIFICATIONS

If this recommendation involves a promotion or change to another job classification answer the following questions:-

1. PRESENT RATE OF PAY $_____ PER _____ 2. RECOMMENDED RATE OF PAY $_____ PER _____
3. RATE OF PAY TO CHANGE WITH PAYROLL BEGINNING _____ 4. DATE OF LAST PAYROLL CHANGE _____ 5. AMOUNT OF LAST CHANGE $_____ PER _____
6. REASON FOR LAST CHANGE: (Check one) ____LENGTH OF SERVICE INCREASE ____MERIT INCREASE ____RECLASSIFICATION ____PROMOTION
7. PRESENT JOB CLASSIFICATION _____ (Standard AWWA&E Co.) 8. RECOMMENDED JOB CLASSIFICATION _____ (Standard AWWA&E Co.)
9. RANGE OF PRESENT CLASSIFICATION _____ 10. RANGE OF NEW CLASSIFICATION _____

VI. LAYOFFS, DISCHARGES OR OTHER SEPARATIONS INCLUDING DEATHS AND RETIREMENTS

If a payroll separation is involved answer the following questions:-

1. EMPLOYEES RATE OF PAY $_____ PER _____ 2. DATE SEPARATED FROM PAYROLL _____
3. JOB CLASSIFICATION AT TERMINATION _____ (Standard AWWA&E Co.) 4. RANGE OF SUCH JOB CLASSIFICATION _____
5. CHECK TYPE OF SEPARATION ____RESIGNED ____LAYOFF ____DISCHARGE ____DEATH ____RETIREMENT ____MILITARY OR NAVAL ENLISTMENT OR INDUCTION
6. DID WE GRANT A CERTIFICATE OF AVAILABILITY ____YES ____NO _____

REASON FOR THIS RECOMMENDATION _____

RECOMMENDED BY _____ APPROVED BY _____

TITLE _____ TITLE _____

FORM W 88

EMPLOYEE PROGRESS REPORT

NAME OF EMPLOYEE | JOB CLASSIFICATION

COMPANY | DATE

In order to obtain a more definite and periodic estimate of the value of each employee to the Company, will you please check each of the eight factors at the place which gives your best estimate of this employee. Read over the definitions for each factor carefully. Decide which definition in the column at the right of each factor corresponds to your estimate of the employee whose progress is being judged. Then check (v) the square which most nearly corresponds to your estimate of the employee on that factor. Further to the right of each factor is a blank space for you to give the reasons for judging the employee as you have. Please be as specific as possible. Below is an example of a rating on Quality of Work:

EXAMPLE OF RATING ON:

1. Quality of work — Is this employee accurate and thorough; is he doing a good job; does he have errors, mistakes and complaints?	☐ 20	Does work excellently – very accurate, minimum mistakes or complaints on work	New employee, 7 months service, not entirely satisfactory, shows improvement in last few weeks
	☐ 16	Does good quality of work – can be depended upon, makes few errors	
	☑ 12	All right on quality – "gets by" under supervision	
	☐ 8	Fair quality – considerable room for improvement	
	☐ 4	Falls down on quality – work frequently unsatisfactory	

Following the eight factors are questions which we request that you answer.

In analyzing the value of an employee to our Company, judgment is the principal faculty used. Exactitude is impossible of attainment because a man or woman cannot be measured like a bushel of wheat. Life would be extremely dull if this were so. Yet we do judge people and their abilities, particularly those we work with. We come by these opinions through observation of the actions of employees on the job until at any given time we can give a judgment on their ability and usefulness.

To aid you in organizing your judgment on employee's merit, this form has been devised. May we have your sincere cooperation?

This form should be filled out by the Manager with the aid of each employee's immediate supervisor, if any. If more than one supervisor is familiar with an employee, he should also be asked to aid you in preparing this analysis.

Keep one copy of this form and send the other to the Home Office in the sealed envelopes, which will be provided for this purpose.

SUGGESTIONS FOR GOOD RATING OF EMPLOYEE PROGRESS

1. Read carefully general suggestions and all factors on the progress report and their definitions before starting to check form.
2. The best manager or supervisor bases his opinions on facts. Base all ratings on facts as far as possible. Think of various facts or reasons which cause you to rate the employee as you do on each factor. Be sure to give your reasons for rating to the right of the factor under column "Explanation: Reasons for Estimate".
3. Improve your ability to judge people by rating each factor and answering all questions carefully. It's worth doing well for you and the employee. Be sincere and accurate. A rating that is too high will be unjust to the Company; a rating that is too low will be unjust to the employee.
4. Compare each employee on each factor to the highest or best and the lowest or poorest employee you have known in recent years with reference to that factor. For example: On quality of work compare the employee being rated to employee whose work was the best or poorest in quality.
5. Consider one factor at a time. Don't let your general impression of the employee affect your rating on one factor. You may not like an employee generally but he may be doing good quality of work. You may like an employee but he may not have as much knowledge of his job as he should.
6. In rating a number of employees, rate all of them on one trait at a time. For example: If you are rating ten employees, rate them all on quality of work first, then all on knowledge of job and so on on all seven factors.
7. Only rate employees who you know well enough to rate – who have been with the Company six months or more.

FACTORS AND GENERAL QUESTIONS	ESTIMATES	EXPLANATION: REASONS FOR ESTIMATE
1. QUALITY OF WORK Is this employee accurate and thorough; is he doing a good job; does he have errors, mistakes and complaints?	☐ 20 Does work excellently – very accurate, minimum mistakes or complaints on work. ☐ 16 Does good quality of work – can be depended upon, makes few errors. ☐ 12 All right on quality – "gets by" under supervision. ☐ 8 Fair quality – considerable room for improvement. ☐ 4 Falls down on quality – work frequently unsatisfactory.	
2. KNOWLEDGE OF WORK Does he know his job well, understand details and requirements of work, know equipment, methods and materials; does he ask intelligent questions; has he a desire to learn?	☐ 20 Knows job thoroughly from a to z; suggests improvements. ☐ 16 Competent worker – good understanding of requirements and working knowledge. ☐ 12 Carries on the job – normal knowledge, willing to learn. ☐ 8 Lacks some knowledge, doesn't know all details. ☐ 4 Often wrong, learner, comparatively new man, inadequate knowledge.	
3. RELIABILITY Can you trust statements which he makes about his work; will he do what he says he will do? Can you believe his reports?	☐ 15 Can trust his statements and reports always. ☐ 12 Can usually trust him. ☐ 9 About average. Tells of mistakes made. ☐ 6 Cannot always trust his statements and reports. ☐ 3 Statements unreliable.	
4. PERSONAL HABITS Are his personal habits good with respect to drinking, sleeping on the job, attendance, lateness, cleanliness and care of workplace, is his personal appearance appropriate to the job?	☐ 10 Habits beyond reproach. ☐ 8 Good, above average personal habits. ☐ 6 Satisfactory personal habits. ☐ 4 Slips occasionally – sometimes has trouble in personal habits, cannot always depend on him. ☐ 2 Slips considerably.	

FACTORS AND GENERAL QUESTIONS	ESTIMATES	EXPLANATION: REASONS FOR ESTIMATE
5. INITIATIVE Does he do things without being told repeatedly, does he take hold of new things well; is he a self-starter?	☐ 10 Needs to be told only once – anticipates what is to be done. ☐ 8 Takes hold well. ☐ 6 Above average. ☐ 4 Needs to be pushed. ☐ 2 Has to be prodded continually.	
6. INTEREST IN WORK Is he interested in his work, does he study his job for improvement?	☐ 10 Keen interest in work. ☐ 8 Good interest in his work. ☐ 6 Passively interested in work. ☐ 4 Not especially interested. ☐ 2 Dislikes work.	
7. HOW WELL DOES HE GET ALONG WITH OTHERS? Is he cooperative with fellow employees, customers, and the public, how does he influence other people?	☐ 10 Gets along excellently with others. ☐ 8 Gets along well. ☐ 6 Acceptable – cooperates reasonably well. ☐ 4 Occasionally causes friction. ☐ 2 Poor cooperation – argumentative, disruptive.	
8. ATTITUDE TOWARD COMPANY Is he watchful of company's interest; wants company to do well; does he think the company is a good place to work?	☐ 5 Has interest of company at heart; likes company very well. ☐ 4 Has high interest for company; favorable attitude. ☐ 3 Never says anything for or against. ☐ 2 Occasionally little sour on company; beefs considerably and doesn't usually mean it. ☐ 1 Something usually wrong with the company.	
TOTAL RATING OF _____ FOR EIGHT FACTORS.		

WHAT DO YOU CONSIDER THIS MAN'S GENERAL ABILITY OR VALUE TO THE COMPANY TO BE?

CHECK WHICH ☐ POOR ☐ FAIR ☐ AVERAGE ☐ GOOD ☐ EXCELLENT

IS THIS EMPLOYEE MAKING PROGRESS IN HIS PRESENT WORK? ☐ YES ☐ DOUBTFUL ☐ NO EXPLAIN

DO YOU THINK HE IS READY FOR PROMOTION IF ONE WERE AVAILABLE? ☐ YES ☐ DOUBTFUL ☐ NO WHY?

IF YES, WHAT JOB OR JOBS DO YOU THINK HE IS CAPABLE OF BEING PROMOTED OR TRANSFERRED TO IF THE JOB OR JOBS WERE AVAILABLE

ATTITUDE OF EMPLOYEE AND FAMILY TO TRANSFER TO ANOTHER LOCALITY ☐ FAVORABLE ☐ UNFAVORABLE

STATE HERE ANY OUTSIDE STUDY OR WORK WHICH THIS EMPLOYEE DOES WHICH MAY HELP HIM IN HIS WORK WITH THE COMPANY

WHAT COMMUNITY SERVICE, SUCH AS WORK FOR VARIOUS CIVIC AGENCIES, DOES HE DO?

DESCRIBE BRIEFLY ANY OUTSTANDING ACHIEVEMENT OF EMPLOYEE DURING LAST 12 MOS.:

ANY CHANGE IN MARITAL STATUS?

ANY CHANGE IN NUMBER OF CHILDREN?

OR OTHER DEPENDENTS?

CHANGE IN HOME OWNERSHIP?

CHANGE IN PERSONAL FINANCES?

CHANGE IN HEALTH?

IS ABSENTEEISM NORMAL ☐ YES ☐ NO IF "NO" WHAT IS CAUSE

PREPARED BY

ASSISTED BY

FORM W 79-43197

EMPLOYMENT RECORD

COMPANY

LOCATION

IF FIRST EMPLOYMENT CHECK HERE ☐

EMPLOYEE'S NAME:			
FIRST	MIDDLE	LAST	SOCIAL SECURITY NUMBER

NOTE: MARRIED WOMEN SHOULD FURNISH FIRST OR GIVEN NAME, MAIDEN NAME AND HUSBAND'S LAST NAME.

PRESENT ADDRESS			
	STREET AND NO.	POST OFFICE	STATE
CHANGES OF ADDRESS	1.		TELEPHONE NUMBER
	2.		
	3.		
	4.		

DATE OF BIRTH:	AGE:	PLACE OF BIRTH:	
MALE ☐ FEMALE ☐	WHITE ☐ NEGRO ☐	HEIGHT_____FT._____IN.	WEIGHT_____LBS.
PARENTS' NAMES	FATHER:	COUNTRY OF BIRTH:	
	MOTHER:	COUNTRY OF BIRTH:	
RELIGION:	MARRIED ☐ SINGLE ☐	IF MARRIED, DOES WIFE OR HUSBAND WORK REGULARLY?	YES ☐ NO ☐

DEPENDENTS	1. NAME:	AGE:	RELATIONSHIP:
	2.		
	3.		
	4.		
CITIZEN YES ☐ NO ☐	IF NATURALIZED CITIZEN GIVE COURT AND DATE OF PAPERS:	IF NOT CITIZEN WHAT IS STATUS:	
MILITARY SERVICE		PENSIONED ☐ HONORABLE DISCHARGE ☐	

MILITARY, FRATERNAL ORDERS, CLUES AND CIVIC ORGANIZATIONS BELONG TO:

LAST TWO EMPLOYERS: NAME AND ADDRESS OF FIRM	KIND OF WORK	DATE STARTED	DATE LEFT	REASON FOR LEAVING
2.				

PERSON TO NOTIFY IN CASE OF EMERGENCY	NAME:		RELATIONSHIP:
	ADDRESS:		TELEPHONE NO.
EDUCATION	CIRCLE YEARS COMPLETED	GRAMMAR—JUNIOR HIGH 1 2 3 4 5 6 7 8 9	
		HIGH SCHOOL 1 2 3 4	COLLEGE OR PROFESSIONAL 1 2 3 4 5 6 7
	NAME AND ADDRESS OF LAST SCHOOL OR COLLEGE ATTENDED:		COURSE OR DEGREE (IF ANY):

REFERENCES (OTHER THAN FORMER EMPLOYERS OR RELATIVES)	1 NAME:	
	ADDRESS:	
	2 NAME:	
	ADDRESS:	

IF RELATED TO PERSONS IN OUR EMPLOY STATE NAMES AND RELATIONSHIP:

REMARKS:

DATE OF APPLICATION

SIGNATURE OF APPLICANT

PERSONNEL RECORD

DATE EMPLOYED:	OCCUPATION:	JOB CLASS.	SUPERVISOR: YES ☐ NO ☐
LOCAL DOCTOR'S REPORT:		REPORT DATED:	RATING:
APPROVED BY HOME OFFICE DOCTOR ON:		DATE EMPLOYEE BECOMES 65:	

RECORD OF SERVICE

DATE	CHANGES IN CLASSIFICATION	NORMAL WORK WEEK	SALARY OR WAGE RATE	SALARY OR WAGE PER	OVERTIME RATE PER HOUR

RECORD OF PROGRESS REPORTS

FACTORS	MONTH AND YEAR										
1. QUALITY OF WORK											
2. KNOWLEDGE OF JOB											
3. RELIABILITY											
4. PERSONAL HABITS											
5. INITIATIVE											
6. INTEREST											
7. GETS ALONG WITH OTHERS											
8. ATTITUDE											
TOTAL											
GENERAL ABILITY											

ABSENCE RECORD	19 :	19 :	19 :	19 :	19 :
	19 :	19 :	19 :	19 :	19 :

CHANGES IN STATUS

MARITAL STATUS:

DEPENDENTS (NUMBER):

FINANCIAL DIFFICULTIES:

HEALTH AND ILLNESS:

SELF IMPROVEMENT:

HOME STATUS (OWNS; RENTS; BOARDS WITH PARENTS):

DATE OF SEPARATION:	DISCHARGED	LAID OFF	RESIGNED	OTHER REASONS:
	INDUCTED	RETIRED	DIED	

REMARKS:

DATE _____ MANAGER _____

Depreciation Committee Report

Introductory Statement

THE National Association of Railroad and Utilities Commissioners (NARUC) at its annual meeting in November 1937, appointed a special Committee on depreciation to render a report to its New Orleans convention in 1938. This report was not accepted by the NARUC as defining its policy. Some changes were made in the personnel of the committee, and a second report was presented by the committee at the 1939 NARUC annual convention. This report was accepted. Nelson Lee Smith, Chairman of the New Hampshire Public Utilities Commission, was made chairman of the committee.

During 1938 and 1939 this special committee had consulted somewhat with members of the electric and gas utilities. Following the NARUC acceptance of its committee's report, these industries undertook to provide the committee with data on depreciation within their industries. During 1940 a considerable amount of information was furnished, and the telephone industry was in the process of gathering information for the committee.

Water works representatives were invited, together with representatives of the electric, gas and telephone industries, to meet with the NARUC committee on depreciation in July of 1940. At a later conference it was agreed to request the American Water Works Association to appoint a committee which would sponsor the collection of data from private and public water works systems.

Early in 1941 a Committee on "Survival and Retirement Experience with Water Works Facilities" was organized with Louis R. Howson as chairman. The New England Water Works Association appointed a cooperating group and the activities of the committee represent the coordinated interest of the two associations. The committee has confined itself exclusively to the development of factual records relating to the removal from service of water works materials. A Progress Report of the committee's work was published in 1942 (Jour. A.W.W.A., **34**: 1585 (1942)).

This committee was directed by the Board of Directors to confine itself to the records of retirement of materials and not to engage in a discussion of the relation of depreciation to plant valuation or rate making. While its findings are expected to have a value in guiding policies with relation to depreciation, they do not relate directly to the NARUC depreciation report.

At the NARUC war conference in 1943 the committee on depreciation submitted a report, "Report of Depreciation Committee, 1943 National Association of Railroad and Utilities Commissioners," for the consideration

and study by member commissioners and for their future action. This report combines the results of four years' study by the committee members. It contains a foreword, a summary and the following chapters:

(1) Outline of Development of Depreciation Principles and Practices;
(2) Current Concepts of Depreciation;
(3) Depreciable Plant;
(4) Depreciation Base;
(5) Methods of Computing Depreciation;
(6) The Estimation of Service Life;
(7) Adjustments of Depreciation Rates and Reserves;
(8) Depreciation in Income Taxation;
(9) Depreciation and the Investor;
(10) Depreciation in Rate Cases.

A summary of this report, prepared by E. H. Aldrich, Supervising Coordinator, A.W.W.A. Committee on Survival and Retirement Experience with Water Works Facilities, is reprinted below.

In January 1944, the Board of Directors of the American Water Works Association, appointed a Depreciation Committee to study the report of the NARUC Committee on Depreciation, for the purpose of determining how it affected water utilities. Members of this Committee are L. R. Howson, Chairman; Charles J. Alfke, John S. Longwell, Dale L. Maffitt, and N. T. Veatch.*

Recently the above Committee concluded its study. On April 27, 1944, its findings were submitted, "Report of the Depreciation Committee of the American Water Works Association on Its Study of the Report of the Committee on Depreciation National Association of Railroad and Utilities Commissioners," and the findings are printed herein (*see* pp. 621).

Report of Depreciation Committee, 1943

National Association of Railroad and Utilities Commissioners

Summary †

The more important conclusions and recommendations contained in this report are summarized briefly below to afford a convenient general preview of the substance of the report as a whole. In summary statements it is obviously not possible to capture all the refinements of meaning or all the particular qualifications set forth in the main text. Therefore these statements are to be taken as condensed expressions of the ideas and principles that are developed more fully in the report.

A. Nature of Depreciation

1. The modern view of depreciation emphasizes the concept that the purchase of capital goods is in essence a purchase of future services.

2. The significance of the depreci-

* Messrs. H. A. Van Norman and Abel Wolman who were appointed to this committee, were compelled, by the other demands upon their time, to forego participation in the discussion of the report.

† Prepared by E. H. Aldrich, *Supervising Coordinator* of the Committee on Survival and Retirement Experience With Water Works Facilities.

tion phenomenon may be described as follows:

(a) Depreciation is the expiration or consumption, in whole or in part, of the service life, capacity, or utility of property resulting from the action of one or more of the forces operating to bring about the retirement of such property from service;

(b) The forces so operating include wear and tear, decay, action of the elements, inadequacy, obsolescence, and public requirements;

(c) Depreciation results in a cost of service.

3. Depletion is the using up of wasting assets—natural resources, such as timber, oil, natural gas, *etc.* Thus it is closely related to depreciation taken on a unit of production basis.

4. Amortization, as applied to fixed assets, is the process of writing off the cost of intangibles, such as patents, copyrights, leaseholds, *etc.*, over a period of time. Such assets frequently have a contractual or legal life over which the cost should be spread.

5. Depreciation accounting is the process of charging the book cost of depreciable property to operations over its life.

6. The physical, functional, and accounting processes defined in the four preceding paragraphs are often referred to collectively, for convenience, as depreciation.

7. In the past, several methods have been employed to account for the consumption of the service or economic life of plant assets, including the retirement, replacement, appraisal, arbitrary write-down, retirement reserve, and depreciation methods. Only the depreciation method survives in general use.

8. There are two interrelated aspects of depreciation: annual expense and accrued depreciation. Annual expense is shown in the income statement; accrued depreciation is recorded in the depreciation reserve, a balance sheet account.

9. Depreciation is the using up of the economic or service life of an asset regardless of the specific factor which may ultimately cause the asset to be retired. It is the exhaustion of service life, not the particular cause of retirement, that is important.

10. Depreciation should not be confused with efficiency. A machine may be highly efficient when near the end of its service life and when it is almost fully depreciated in fact.

11. While the progress of depreciation may be retarded by proper maintenance, the view that maintenance prevents depreciation is unsound. Regardless of the degree of maintenance, economic life cannot be prolonged indefinitely.

12. The depreciation reserve measures that part of the cost of plant still in service which has been written off, usually as an operating expense. If the depreciation reserve has been properly determined, it measures the accrued depreciation. The depreciation reserve should preferably be shown on the asset side of the balance sheet as a deduction from depreciable plant.

13. The depreciation reserve is an account *contra* to the plant account. It is not a fund. Depreciation accounting normally results in the retention in the business of assets which otherwise might be distributed as dividends. Ordinarily these assets are not earmarked and, with minor exceptions, there is no reason why they should be.

14. The financing of replacements is not the purpose of depreciation ac-

counting. Its purpose is to record as a cost of operations, the *pro tanto* cost of property consumed therein, thus maintaining the integrity of the investment whether or not replacement occurs. Where depreciation is computed on a base higher than the actual cost of properties, accretions to capital result; where the depreciation base is lower than the actual investment, capital impairment follows.

B. Depreciable and Non-Depreciable Property

15. In practice a distinction is made between depreciable and non-depreciable assets. Non-depreciable property is, in fact, only that property which has unlimited life in service. Mere longevity, or the difficulty of predicting service life should not prevent provision for depreciation according to the best information available.

16. Overheads—including interest during construction—and indirect costs, to the extent associated with depreciable plant, represent depreciable costs. Such overhead and indirect costs should be assigned to units of property so that the full costs of the property units can be spread over their respective service lives.

C. Basis of Computing Depreciation

17. Depreciation should not be based upon fair value or replacement cost. In this respect the doctrine followed in *United Railways & Electric Co. v. West* (280 U.S. 234, 253, *1930*) miscontrues the economic nature of depreciation and would be administratively impossible of reasonably accurate application.

18. Depreciation expense should be based upon the cost of depreciable assets. The actual cost to a utility of properties acquired as operating units or systems may differ from their original cost. Under most current systems of accounts for utilities it has been established that depreciation shall be based on original cost.

19. Any difference between the cost and original cost less depreciation is recorded in the acquisition adjustment account. Since the proper disposition of amounts in this account must depend on the circumstances which gave rise to them, no specific rules for their accounting treatment are recommended.

D. Depreciation Methods

20. Several methods have been used to compute public utility depreciation, but only three are generally recognized or accepted today. These are the straight-line, compound-interest (modified sinking-fund), and sinking-fund methods.

21. The straight-line method is in very general use and is in the ascendancy in the public utility field.

22. The straight-line method is simpler than, and is not as seriously affected by errors in estimates of service lives as, the interest methods.

23. At all times prior to the end of the service life of a plant unit, the straight-line method results in a higher depreciation reserve than do the interest methods. In the case of long-lived plant and where a high interest rate is used under the interest methods, the difference between a reserve computed by the straight-line method and one computed according to the interest methods will be substantial. Conversely, the reserve computed according to the interest methods will approach the straight-line reserve as the interest rate approaches zero.

24. The straight-line method results in higher charges to consumers for de-

preciation and return (assuming the same rate of return) when property is young, and lower charges when property is old, than does either of the interest methods. It can be argued that under the "present-worth" theory the real cost to consumers in the long run will be the same, regardless of the depreciation method, provided no extra profit accrued to the utility because of a differential between the sinking-fund interest rate and the rate of return. The total dollar charges to customers in the long run, however, will be greater under the sinking-fund or compound-interest methods than under the straight-line method.

25. The compound-interest method, which is also called the present-worth method, and the sinking-fund method, which is a modification of the former, yield the same results in the aggregate, where the depreciation reserve requirement is deducted under the compound-interest method and where the interest rates under both methods are the same as the rate of return.

26. The straight-line method is generally recommended for public utility accounting and financial purposes and also for the computation of both depreciation expense and accrued depreciation for purposes of rate making.

27. Depreciation rates may be applied to individual units of depreciable property or to groups of units. The group plan has many advantages and should be used wherever property can rationally be grouped.

28. The determination of depreciation rates according to any reasonable procedure involves the use of judgment in the application of methods. Statistical data drawn from property experience and applied with judgment based on knowledge of the property should be given much greater weight than general judgments based principally on observation of the property.

E. Current Charges and Adjustments of Reserves

29. Current charges for depreciation expense should be based upon the best possible estimates of the amount properly applicable to the period covered by an income statement, without modification for excessive or deficient charges in the past.

30. The depreciation reserve should not be readjusted gradually through modification of the annual depreciation rates when the difference between the book reserve and the proper reserve is substantial. When the difference is not substantial it is satisfactory to spread the remaining net cost of the properties over their remaining lives.

31. In principle, any necessary correction of depreciation reserves should be made through surplus or a special section of the income account. However, the adjustment of inadequate depreciation reserves, while sound in theory, presents many practical difficulties. Where such deficiencies are serious, it is desirable to make every effort to adjust them, although it is recognized that the application of a uniform rule without regard to what is equitable and feasible under the circumstances of individual cases might cause injury to security holders out of proportion to the long-range benefits. Therefore, it is concluded that the objective of correcting inadequate reserves should be approached with appropriate consideration of the practical effects of alternative courses of action.

F. Depreciation in Income Taxation

32. Because of certain special problems and provisions of the federal income tax laws and regulations, absolute

consistency between the treatment of public utility depreciation for tax, corporate and regulatory, may not now be feasible, but such consistency should be sought to the greatest practicable extent.

33. Inconsistencies between the treatment of public utility depreciation for income tax, corporate, and regulatory purposes have sometimes been unjustifiably great and often have been inadequately disclosed with attendant effects upon the tax liabilities of stockholders. Analysis of substantial differences in the treatment of depreciation for these respective purposes is necessary, both for the protection of the investor and for fully effective regulation.

34. Since the depreciation reserve builds up more rapidly under the straight-line method than it does under the interest methods, the use of the straight-line method tends to reduce the investors' risks and therefore to lower the cost of capital.

G. Depreciation and the Investor

35. Failure to make adequate provision for depreciation results in the impairment of capital, unless an appropriate retention of surplus is made. Depreciation policies and practices should, therefore, be taken into account in the consideration of questions of public utility finance.

36. Although the immediate interests of equity—and debt-holders may sometimes conflict—and although the short-run and long-run interests of investors as a class may sometimes differ, adequate provision for depreciation is essential to the protection of the interest of investors, taken as a whole and from a long-range point of view.

H. Depreciation in Rate Making

37. The same factors which cause annual depreciation expense also cause accrued depreciation. Accordingly, the same principles should be applied in determining annual depreciation expense and in determining accrued depreciation.

38. So-called observed depreciation is not accrued or existing depreciation. Depreciation is not visually observable; only the physical effects of some of the forces which operate to cause retirement can be observed.

39. A properly computed depreciation reserve is the best measure of accrued or existing depreciation, since such reserve reflects that part of the cost of the property in service which relates to the exhausted or expired economic or service life.

40. In fixing public utility rates adequate depreciation expense should be allowed according to the service life basis and, in principle, the reserve requirement determined on the same basis, should be deducted in determining the rate base. There are cases, however, where equity requires the deduction of the book depreciation reserve, even though it differs materially from the reserve requirement. The determination as to when this condition exists involves, among other things, consideration of the history of regulatory requirements in the jurisdiction and the experience and practices of the company. In other words, individual situations should be dealt with by the commission having jurisdiction in accordance with the facts in each case.

41. The use of the straight-line method in determining both depreciation expense and accrued depreciation is generally recommended for rate-making purposes.

42. The sinking-fund method may sometimes be used in rate making when it is impracticable to determine the accrued depreciation. When the sinking-

fund method is used in rate proceedings, the interest rate employed should be the same as the rate of return which is applied to the undepreciated rate base.

I. Responsibility of Management and Public Accountants

43. Management and public accountants have a responsibility to indicate in financial statements the proper depreciation expense and the reserve requirement, according to their best information after appropriate study, in those instances where the book figures are inadequate or excessive in a material amount.

Special Report of the Depreciation Committee of the A.W.W.A.‡

This discussion is submitted by the Depreciation Committee of the American Water Works Association appointed by the Board of Directors of the American Water Works Association on January 20, 1944 to study the report of the NARUC Committee on Depreciation and advise relative thereto as affecting water utilities.

The American Water Works Association is the largest association of water works men in the world, representative of the more than 12,000 water works in the United States, of which approximately 80 per cent are municipally-owned and operated. Depreciation occurs and must be financed irrespective of ownership although the factors affecting depreciation methods and policies are influenced to some extent by the ownership.

In only a few states are publicly-owned utilities subject to regulation. Their depreciation methods and policies are therefore largely determined locally. Publicly-owned water utilities in general set up larger depreciation reserves than the private companies and ordinarily use the straight-line method for annual allowances. The reserve thus accrued frequently bears no direct relation to the actual accrued depreciation of the property. This policy of liberal reserves provides funds required for plant additions and obviates delays and costs incident to bond issues otherwise necessary.

Most privately-owned utilities are operated under governmental regulation and the annual depreciation allowance is either fixed or approved by the regulatory body. Their accrued depreciation and present value are usually checked at more or less frequent intervals in studying the fairness of rates for service. As a result of several decades of regulation the privately-owned utilities usually maintain a closer balance between annual and accrued depreciation and the actual requirements for each property.

The entire water works industry is alert to the importance of depreciation and is accordingly appreciative of the service performed by your committee in its study of the depreciation question. In this discussion we present only the major points on which the

‡A report submitted on April 27, 1944, to Nelson Lee Smith, Chairman, NARUC Committee on Depreciation, Federal Power Commission, Washington, D.C., by the Depreciation Committee of the A.W.W.A., Louis R. Howson, Chairman, Chas. J. Alfke, John S. Longwell, Dale L. Maffitt, N. T. Veatch, Abel Wolman and H. A. Van Norman, who were appointed to this committee, have been unable to participate on account of the exigency of other matters.

views of the water utilities differ from those expressed in the NARUC Committee report. Some of these differences may be common with other utilities and some of them peculiar to the water works industry.

The water works is the oldest utility in the field. Approximately two-thirds of the value of the average water works is in its distribution system, which for the past 125 yr. has been constructed preponderantly of cast iron, a material having an exceedingly long life and slow rate of depreciation. For illustration, of the 7,242,534 ft. of 6-in. pipe installed in the Philadelphia water works beginning in 1821, the retirements total but 312,352 ft. (4% +), and the survival ratio is 84.3 per cent. Similarly, at Utica, N.Y., with a 92-yr. record covering a total installation of 596,806 ft., but 10,972 ft. (less than 2 per cent) have been retired and the survival ratio is 90.0 per cent. For the first fifteen water works plants covered by the survey of the A.W.W.A. Committee on Survival and Retirement Experience with Water Works Facilities, the average survival ratio (covering 34,654,567 ft. of 6-in. and larger cast-iron pipe) is 93.1 per cent. The average experience record of these fifteen plants is 66.3 yr.

These few figures are sufficient to emphasize the great difference of age and life figures for the water utility as contrasted to some of the units in electric, telephone, telegraph and other similar shorter lived, high development and higher mortality type utilities.

While the distribution systems constitute a large percentage of the investment in water works systems, the remainder of total investment, such as water supply, purification works, pumping facilities, etc., also generally have comparatively long usefulness.

Inquiry from 181 private water utilities yielded the following weighted average figures:

% which annual allowance for depreciation is of depreciable book cost	.99
% which depreciation reserve is of depreciable book cost	13.4
% which earned surplus is of depreciable book cost	6.25

We respectfully submit the following views which are at divergence with views expressed in the NARUC Committee report:

1. Our group has no disagreement with the general principle that accrued depreciation and annual allowances must be reasonably in step (pp. 151 *). We do disagree completely with the applicability of the straight-line theory in the determination of accrued depreciation of long-lived water works structures. We hold that the accrued depreciation reserve must be closely related with the facts of depreciation and most water works property does not depreciate in a straight line.

We believe the proper annual allowance for depreciation on water works structures of long life is arrived at by a careful determination first of the actual depreciation accrued to date, and from that a determination of the annual rate; both the annual rate and the accumulation in the reserve should be periodically reviewed, and the annual allowance adjusted if necessary to bring it into closer harmony with the actual depreciation requirements.

The determination of the actual accrued depreciation involves a careful inspection of the property by one properly qualified through a background of design, construction and operation of similar properties; a careful study of operating and maintenance records * a

* NARUC Report.

study of the past and probable future needs for the service which the unit or property performs and its ability to meet them; the history of this unit or property and others of its type under comparable conditions, the presence or apparent imminence of obsolescence and other factors that affect the future usefulness in the particular property being studied.

2. In our view the existence of depreciation and the extent to which it exists is a question of fact. Annual allowances are a means of financing that fact in the amount and at the time it occurs. No method of financing can add to or detract from what the NARUC Committee report terms "actual" depreciation. The adoption of the sinking-fund theory with no deduction for accrued depreciation, as advocated on page 170 (NARUC report), cannot affect the "actual" depreciation in a property. It affects only the accounting procedure; neither can the allowances for annual depreciation by the straight-line method govern the "actual" depreciation of a property. That, too, only affects the accounting procedure. Both sinking fund and straight-line methods of determining the amount of annual allowance are simply means of financing a fact.

We submit that "actual" depreciation is independent of any method of financing and that for any particular class of property that method is best which most closely harmonizes the facts and their financing.

Where a conflict occurs the theory should be modified to conform to the facts rather than the facts warped to meet a theory such as the straight-line theory which is in general not applicable to the long-lived water utility property.

3. The adoption of straight-line depreciation for long-lived property produces a depreciation reserve greatly in excess of the requirements for depreciation and frequently in excess of the amounts that can be reinvested in the property.

In view of the fact that most private water companies acting under public utility commission regulation have been setting up less than 1 per cent per yr. for depreciation and now have reserves averaging less than 15 per cent of book cost, it would be manifestly unfair to deduct 25 per cent to 40 per cent for accrued depreciation computed by the straight-line method. Experience longer than that of any other utility has demonstrated the general adequacy of both the present annual charges and the reserves which they have accumulated. The balance should not be disturbed except in those properties which are exceptions to the above statement.

4. *Annual* allowances for depreciation must be sufficient to cover contingent depreciation, that resulting from casualty, as well as other forms. The *accrued* depreciation does not reflect casualties *until they occur.* Because of this fact the balance in the depreciation reserve usually should be somewhat larger than the actual accrued depreciation. For illustration, a proper *annual* allowance for depreciation for the Cinicinnati water works should have reflected some provision for the contingency of a flood as high as that of 1937, even though such a flood had not occurred in more than 100 yr. of operation. However, the *accrued* depreciation of the Cincinnati water works did not and could not reflect that contingency until the unprecedented flood occurred.

A part of a proper annual depreciation allowance is for contingencies just

as a part of automobile insurance covers collision contingency. The fact that the average automobile may sustain a $250 collision damage once in five years, cannot possibly detract from the value of a car not yet smashed up. Thus the annual allowance for depreciation on a water works must contain provision for contingencies but the depreciation does not actually accrue until the contingency happens.

5. With short-lived properties the divergency between sinking-fund, present-worth and straight-line annual allowances is small, but with facilities of such long lives as water mains the difference is relatively large.

The NARUC report states: "The total dollar charges to customers in the long run, however, will be greater under the sinking-fund or compound-interest methods than under the straight-line method." We submit that this statement can only be true if it be assumed that what the customer saves in the early years when interest methods are used, earns no interest during the entire period, which seems to us an unjustified assumption.

If the amount which the customer saves when depreciation is set up on a sinking fund basis as compared to a straight-line basis is credited with interest at the rate upon which the annuity is determined, the cost to the customer over the life of the property will be precisely the same under the two alternatives. However, by straight-line the earlier generations will be contributing to the cost of service to the later generations and the depreciation reserve will be collected in the early years at a rate much greater than needed to cover retirements or compensate for actual depreciation.

6. With long-lived structures such as water mains, the inapplicability of straight-line depreciation becomes most apparent. Its use creates reserves far in excess of the needs of most long-lived properties. With so little mortality experience as is available for such items as cast-iron mains, the estimate of life is so much of a pure guess and the net salvage at that remote period even more so, that we insist that the method outlined herein in (1) is more practical and equitable.

7. It is believed that the repeated use of the word "actual" in connection with statements such as the following, "The deduction of the depreciation reserve * * * harmonized depreciation expense and *actual* existing depreciation" and "The reserve should be deducted in arriving at the rate base, *for the reserve alone measures actual* depreciation" is both inaccurate and unfortunate. It is believed that the determination of accrued depreciation by taking the amount in the reserve computed on "straight-line" as applied to water works, is rather an accounting expediency rather than a measurement of the *"actual"* depreciation which the property has suffered. It is believed to be correct only on the dates the property goes into service and when it is 100 per cent depreciated. With long-lived water utility facilities the divergence at intermediate periods is greater than for any other utility.

8. The consumers through rates are obligated to keep the owner's investment intact. Their payments must be adequate for depreciation *as it accrues.* There is no reason why the consumer through the depreciation reserve should provide an excess over the requirements and finance capital expenditures which is the usual result of the use of "straight-line" depreciation.

9. While the NARUC report is primarily with respect to depreciation it

seems to carry throughout the inference that depreciated original cost should be the rate base rather than "fair value." We see no reason why utilities should not follow the same economic laws affecting value as all other property values which are based upon "fair value."

10. The report recommends that present reserves be brought up to the amount computed on a straight-line basis by withdrawals from surplus or a special section of the income account. Present reserves in most cases result from several decades of rate regulation and in general are a reflection of demonstrated requirements. To adjust the reserve arbitrarily in this manner and with the above background is unfair. It shifts the charge for added depreciation from the *consumer* to the utility and violates the fundamental concept of the consumer's obligation to finance the consumption of investment through rates.

11. Conclusion 30 states: "The depreciation reserve should *not* be readjusted gradually through modification of the annual depreciation rates when the difference between the book reserve and the proper reserve is substantial." Conclusions 39 and 41 define the proper reserve as being the accrued depreciation determined by the straight-line method. As stated earlier herein, the present private water company depreciation reserves accumulated under regulatory direction average but 13.4 per cent of depreciable book cost. The straight-line accrued depreciation would probably average 25 per cent or more. That is a substantial difference which your report states should *not* be made up by modifying the annual depreciation rates. This stipulation closes the door to the only means of equitable adjustment available and it is recognized that even the collection of the arbitrary increase in depreciation from future customers is inequitable to the extent that future and past customers are not the same. This suggests the desirability of maintaining "status quo."

12. As the utilities cannot go back and collect more from the consumers of the past for depreciation and under the report are prohibited from making it up by larger collections for depreciation in the future, the values of the properties are necessarily impaired. Requiring the utilities to deduct from capital that which they were never permitted to collect through rates is contrary to all precedent and ethical procedure.

Water Purification Methods Involving Sodium Silicates

By Harold R. Hay

THE acceptance of sodium silicates in water purification became assured when it was discovered that the presence of silica in very small amounts materially assists floc formation (1, 2). With this knowledge successful methods were developed to improve coagulation in waters from Lake Michigan and from the Mississippi and Missouri Rivers. The usefulness of the new technics has been demonstrated in Colorado mountain streams (3), the flood waters of West Virginia (4), the Mississippi at New Orleans, La., (5) and in many well waters of Florida (6). Favorable results in foreign countries have also been reported (7, 8).

Present curtailment of construction gives major significance to any possibility of increasing existing plant capacity. It is reported (9) that as much as a 25 per cent saving in settling time and filtration area may result with the use of silica coagulant aids. Through the adoption of silicate processes at numerous water plants within the past year a broader experience with these accessory coagulants has been obtained and new methods for their preparation have been discovered. In view of these factors, consideration of silicate treatment at many municipal and industrial water purification plants is warranted.

A paper presented on November 18, 1943, at the Florida Section Meeting, Fort Lauderdale, Fla., by Harold R. Hay, Chem. Dept., Philadelphia Quartz Co., Philadelphia, Pa.

Chemistry of Sodium Silicate Coagulant Aids

The direct application of soluble silicates for corrosion control has been a fairly common practice for many years (10) and their use at numerous military camps has been a noteworthy wartime development. A recent U.S. Public Health survey (11) lists 32 towns, mostly in Illinois and Indiana, where sodium silicates are regularly added to the finished water to protect pipelines. These are generally well supplies which have been zeolite treated. In addition, waters low in natural silica sometimes require sodium silicate prior to softening by zeolites to maintain base-exchange efficiency. As a coagulation aid, however, the use of soluble silicates is more complex and requires some understanding of the chemistry involved.

The term "water glass" was once applied to sodium silicates owing to the water-soluble glass-like form in which they are manufactured. Lump, powdered and liquid grades of soluble silicates are available, but only the liquid type, sold as concentrated as convenience will permit (12), is used in current coagulation practice.

Sodium silicates are chemicals of variable composition characterized principally by their weight ratio of sodium oxide (Na_2O) to silica (SiO_2). This closely approximates, but is not equal to, the molecular ratios. Commercial grades range from ratios of 2:1 through 1:4. Highly alkaline grades are used for detergent purposes. The siliceous products have a wider variety of applications, including water purification. The most economical and satisfactory grade of sodium silicate for coagulation purposes approximates a 1:3.2 ratio. Products of this ratio may be purchased at slightly different concentrations, the most usual about 41° Bé.

The following average analysis of the recommended grade will assist in necessary calculations: Na_2O, 8.9 per cent; SiO_2, 28.7 per cent; H_2O, 62.4 per cent; weight, 11.60 lb. per gal. It is important that the operator be familiar with the analysis of the grade purchased. The only checks required on composition are a hydrometer reading on a sample brought to 20°C. (68°F.) and an alkali titration. For the latter, a calculation of the Na_2O is based on an accurately weighed sample of about 10 g. diluted with distilled water and titrated to a methyl orange end point with acid of known normality.

Soluble silicates are not hazardous chemicals, although the alkali content of some and the adhesive character of others may cause skin irritation if not promptly washed off. The concentrated solutions should not be allowed to remain in open containers because of "skin" formation. Neither should they be permitted to freeze, since some separation will result. This is not serious provided the silicate is warmed and adequately mixed to restore uniformity.

Colloidal Nature of Silicates

Some of the more alkaline sodium silicates exist as crystalloidal chemicals but other grades are highly colloidal. This colloidal silica is considered to be present in structures known as micelles, which vary in size with the Na_2O to SiO_2 ratio and the extent of dilution. The colloidal silica becomes the coagulant aid either alone or in combination with certain metal oxides or metallic silicates.

Practically all methods of preparing the coagulant aid involve a release of the silica from most of the alkali, followed by an aging period during which micelle growth occurs. When the desired micelle size has been reached, proper dilution essentially halts further growth. The stable silica sol thus produced for coagulation purposes is sometimes referred to as being "activated." This silica is highly hydrated and bears a negative electrical charge. The charge and the power of contraction (syneresis) may be plausible explanations of its efficacy. The negative charge may be reduced or neutralized by an acid, by multivalent positive ions or by colloids having a positive charge.

Color and turbidity frequently exist in raw water as negatively charged colloidal particles. These neutralize the charge of the positive colloids produced when alum or iron salt coagulants are dissolved in most waters. If the negative colloids present are inadequate for good floc formation, they may be increased by the addition of certain clays or, more effectively, by an active silica sol. At certain pH values, however, the alum and iron coagulants may develop a negative charge (13) the same as the silica particles. Then the silica sol would not promote coagulation but would contribute stabilization. Gen-

erally it has been found that the use of a silica sol greatly extends the range of pH over which the coagulants give good flocculation (1, 2, 14).

Control of Sol Stability

If colloidal micelles of silica are permitted to grow without being retarded, their size may become so great as to interlock and form a wet gel. When dried, these gels are useful chemical catalysts and moisture absorbents. In water purification the formation of a wet gel is to be avoided. Negligence in following recommendations may, under some circumstances, result in gels sufficiently stiff to plug lines and require shoveling from mixing tanks. Latest developments, however, minimize the possibility of gelation.

In general, careful consideration of the SiO_2 content, concentration of other added materials, temperature, time and degree of neutralization (determined by residual alkalinity) will allow rather precise control of sol stability. Conditions may be chosen which make gel formation virtually impossible. It is not difficult to become familiar with this reaction and to maintain safe control of it. Large and small plants, by following recommendations of those who have developed or worked extensively with the silicate processes, have operated for years without encountering gelation.

Coagulation Methods Involving Sodium Silicates

Combinations with Acids and Acid-Forming Gases

Prior to the successful development of a method employing acid-neutralized sodium silicates, two efforts in this direction had failed to receive acceptance. The Nahnsen patent (18), issued in 1889, was the earliest attempt, but the quantities used were so great that the method attracted no attention. Smith (30) found a retarding effect from a silicate preparation similar to those now commonly adopted. This resulted from the use of an excessive dosage (50 ppm. SiO_2) which is now known to be detrimental. In 1936, J. R. Baylis, of the Water Purification Div., Chicago, Ill., developed a process based on partial neutralization of a sodium silicate (1). Through very careful experimentation, he made such important contributions that adoption of this coagulant aid became assured. Baylis starts with a soluble silicate (ratio 1 : 3.2) diluted to 1.5 per cent SiO_2. Its alkalinity is then reduced by acid neutralization to 1,100–1,250 ppm.; the resulting alkaline sol is aged for 2 hr. and diluted to less than 0.6 per cent silica. A very efficient coagulant aid is obtained. This procedure involves neutralization of approximately 85 per cent of the alkali with release of the associated SiO_2.

As a result of the detailed investigation by Baylis, it is planned to incorporate this process in the new South District Filtration Plant at Chicago (9, 19). This project, now being completed, will be the world's largest water purification plant, capable of treating 576 mgd. of Lake Michigan water during the summer months and 432 mgd. in winter. In an article (19) compiled by various Chicago officials concerned with the project and referring to the silicate treatment, it is stated: "Without the use of silicate the water would not filter as clear as silicate-treated water. . . . Water of better quality will be produced in the winter months by use of the silicate treatment even though coarser sand and faster rates of filtration are used. When the consid-

erable savings in plant costs are taken into consideration, the economy of using silicate is clearly indicated. From the standpoint of better quality of water alone, its use is justified."

A cost analysis given in the same article discloses that during the winter months, when weak coagulation is experienced, the chemical cost of treating with straight alum exceeds that of the silica sol plus alum by 5 per cent. During the summer months, the alum requirement is so low as to be about 15 per cent less costly than the Baylis process. The elimination of a portion or all of the Baylis acid costs, by means to be described, would give greater savings during winter months and reduce the margin favoring alum for summer usage.

In addition to its installation at Chicago, Baylis sol is being employed at Des Moines, Iowa, at several cities in Florida and at industrial plants in Texas, California and Michigan. Plans have been made to include it in numerous postwar construction projects.

In his patent (20), Baylis discloses that various acids other than sulfuric may be used and also acid-forming materials. In the latter category, mention is made of carbon dioxide. This might be developed into a feasible method since many plants have or are planning processes involving recarbonation. A fraction of the carbon dioxide might be diverted for silicate neutralization. Other gases which could be used with expectation of similar active silica sols would be sulfur dioxide and sulfur trioxide.

An interesting possibility is the use of chlorine for sol preparation. When chlorine is passed into a dilute solution of a sodium silicate, the reaction forms sodium hypochlorite and sodium chloride with the liberation of colloidal silica. Thus, a highly effective sterilizing agent and a silica sol coagulant aid are produced simultaneously. The introduction of such a mixture at the coagulating basin would provide a convenient pre-chlorination treatment with savings in the acid cost of the silica sol.

Combinations With Alum and Iron Salts

This important class of silica coagulant aids was developed by A. V. Graf and W. B. Schworm of the St. Louis, Mo., Water Dept. (15). With the use of 1 per cent solutions they report (2): "It was determined that a ratio of one part of sodium silicate to four parts of aluminum sulfate gave the best results with the water treated at St. Louis." In this method the silicate and alum are added in the final proportions used for coagulation. The mixture is acidic and lacks stability. This, however, is not a drawback to a method such as this one which employs continuous rather than batch preparation. The preparation must be added to the water soon after mixing to obtain the desired result. Combinations of the silicate and ferrous sulfate likewise gave improved coagulation.

The Graf-Schworm process has been in use during periods of difficult flocculation at the St. Louis Chain of Rocks plant since 1937. According to present plans the method will be adopted at the newer Howard Bend plant when equipment becomes available. A similar application is in use at Lima, Ohio, where the alum consumption was so materially reduced (16) as to offset the silicate cost and produce an over-all saving. St. Charles, Mo., Crooksville, Ohio, and New Lexington, Ohio, are also said to be operating on

a silicate alum process. At most of these points the chemicals are added separately, although introduced close together. The use of a silicate alum process has also been described in a patent issued to Baylis (20).

At Wheeling, W.Va., a silicate combination with ferrous sulfate is used during flood periods (4). A. R. Todd of the Wheeling Water Works found that when Ohio River water contains more than 0.3 grains (5 ppm.) of natural SiO_2, good coagulation is obtained with ferrous sulfate alone. When there is less than 0.3 grains SiO_2, the deficiency is met by using the silicate-iron-salt combination. A saving in coagulant chemicals is effected.

The N-Sol B process was developed by C. L. Baker and C. H. Dedrick (17) of the Philadelphia Quartz Co. These investigators produce a stable sol by combining the sodium silicate and a portion of the total alum or iron salt to be used. Again, the reaction upon the silicate of a salt of a weak base and a strong acid, lowers the titratable alkalinity, but when still considerably on the alkaline side the mixture is aged and diluted. The metal silicate, together with the colloidal silica thus prepared, may be stored without the formation of a precipitate. This coagulant aid is mixed into the raw water and is followed by the remainder of the alum or iron salts to be used. A very marked improvement in flocculation is frequently noted. It is believed that the insoluble colloidal silicates act as foci or nuclei for precipitation and accelerate the formation and settling of the desired floc. Successful plant runs using this technic have been made with both continuous and batch methods of preparation.

Combination With Ammonium Salts

All methods heretofore discussed for silica sol preparation have been accompanied by a reduction in the titratable alkalinity. In the N-Sol A process, developed by the author for the Philadelphia Quartz Co., the alkalinity is not reduced and thereby new characteristics are contributed to the sol. Investigations show that the addition of an ammonium sulfate solution to a dilute sodium silicate results in a silica sol which is an active coagulant aid. It may be assumed that sodium sulfate is produced (just as from the addition of sulfuric acid) but there would also be at least a theoretical formation of ammonium silicate. Hydrolysis of this product would be expected and the formation of a silica sol and ammonium hydroxide is believed to result. The ammonium hydroxide maintains the alkalinity of the prepared sol thereby delaying gel formation. This permits a higher SiO_2 concentration than that with acid neutralization and smaller mixing and storage equipment is required.

In Baylis sol the alkali neutralization is about 85 per cent complete. A 95 per cent neutralization results in almost instantaneous gel formation. An excess of acid produces a stable sol but one which is reported to be of little use as a coagulant aid. In an ammonium sulfate sol of the same SiO_2 content as Baylis sol it is possible to release all of the SiO_2 in active form without encountering dangerous gel conditions. Furthermore, an excess of this sulfate may be added without lessening the coagulating values.

Another advantage of the N-Sol A process is that the ammonia content remains available for subsequent conversion to chloramine. The cost of

ammonium sulfate required for chloramine treatment is therefore deductible from the cost of sol preparation. At many water plants this consideration and the convenience of ammonium sulfate result in total elimination of acid and its attendant hazards (6). Results on the use of N-Sol A in pilot plant and full plant operations are discussed in a paper (6) by Prof. A. P. Black of the University of Florida. When chloramine dosage or cost factors do not warrant the addition of enough ammonium sulfate to release the silica properly, other chemicals may be used in combination with it.

Many ammonium compounds other than the sulfate are available for sol preparation. Likewise, a silica coagulant aid, intermediate in characteristics between the ammonium salt type and alum or iron salt combinations, may be produced with compounds such as aluminum ammonium sulfate or iron ammonium sulfate. Ammonium alums have had limited application in water treatment and all three components of the alum would serve useful functions in the production of a silica coagulant aid.

Silica sol preparation with sodium bicarbonate, sodium bisulfate, mono- and di-sodium phosphates, ammonium phosphates and similar compounds will be considered by the author in a subsequent article. The advantages of some of these chemicals will be in the form of concomitant products.

Miscellaneous Siliceous Applications

In laboratory investigations, various siliceous materials have been used as coagulant aids. Baylis found (21) that silicon tetrachloride added to water containing alum aided flocculation, but no effect was obtained if introduced prior to the alum. Lordley and Smith (22) report "silicic acid," alone or treated with caustic to 1,200 ppm. alkalinity, had no value. From experiments with various lump and powdered forms of sodium silicates they concluded that only one was sufficiently soluble for consideration. Its identity was not revealed though greatest likelihood of success would result from a finely powdered, highly alkaline grade or a more siliceous but hydrated form. High alkalinity would require large amounts of reactants to dissociate the SiO_2, while the hydrated solid silicates are somewhat expensive for water treatment.

Many patents disclose water treatment processes involving sodium silicates. These are frequently limited to treatment of oil wastes and, as such, present a separate subject. Other patents have little commercial, technical or theoretical significance. The possibility of applying the powdered forms of soluble silicates in a dry feed with ammonium, aluminum or iron salts deserves consideration. The silicate, however, dissolves slowly and the other more soluble chemicals might react on the surface of the silicate to reduce solubility further.

The most siliceous grade of sodium silicate, having a ratio of 1 : 4, may in some instances be sufficiently colloidal for use as an accessory coagulant without neutralization or other type of reaction. It must be determined in this case that the presence of the untreated alkali would not produce undesirable effects.

Factors in Process Selection

It is now recognized that silicate coagulant aids may be prepared by various means. This permits a selection to conform with standard practices and chemical usage at the individual water

plants and to minimize chemical purchase. The methods vary in ease of application; with the more involved procedures there are often compensating benefits.

Before completing a laboratory evaluation of sodium silicates for coagulation, three general methods should be tried. The two metal-salt conbinations previously described may give different results and each should be tested. For the third type it will generally be found that results are similar with any properly prepared silica sol produced with an acid, acid-forming material or simple ammonium salt. Consideration should be given to a proper balance of colloidal silica and coagulant added to the water to be purified. The dosage should be studied to determine the most economical treatment during average conditions and at the extremes of variation in character of the water supply. For larger cities a comprehensive cost study may be in order (5). In some cases it is economical to apply silicates only during periods of difficult flocculation.

Adoption of a silicate method may be influenced by numerous factors too limited for generalized discussion. Residual aluminum or iron oxides, ammonia or chlorine may render the finished water unsuitable for some purposes. Mineral acids may be considered excessively hazardous. Color removal may dictate the choice of method or, more particularly, the order of addition of the silica. High velocity flow may break up a floc produced by one method but not the tougher type produced by another. A sticky floc may be objectionable in some equipment but desirable in a different design. Silicate flocs may prove "too efficient" in speed of formation and settling, whereupon a less active form would be required. The flexibility now developed for silicate coagulant aids permits their satisfactory application under diverse circumstances.

It is, of course, important to follow the effect upon the bacterial content of the water when considering a silicate process associated with the sterilization of the water. This would be true of chlorine neutralization and also of ammonium salt reactions anticipating chloramine treatment. Silica sols prepared with ammonium salts should be used with caution unless chlorination follows soon after they are added to the water. These methods combining coagulation and sterilization involve a pretreatment early in the plant system and should assist in algae control. In the case of chloramine the longer period of contact would tend to offset its slower sterilizing action.

Advantages Gained From Silicate Treatment

The general benefits of sodium silicates in flocculation have been discussed in numerous articles (1, 2, 6, 8, 16, 21, 22, etc.). Many new advantages are just becoming evident. The first effects noticed were greater ease of coagulation owing to the size and density of the floc, its speed of formation and its inherent toughness. These characteristics permit higher flow rates without increased turbidity going to the filters. A shorter retention period in the mixing basin or flocculators, as well as in the clarifiers or settling basins, has permitted some plants to meet increased demand without new construction. Longer filter runs are repeatedly observed. Baylis reports a saving in plant construction through high filter rates obtainable by increasing sand size. Without silicate

treatment excessive sand penetration of the floc could result.

An interesting characteristic of the alum-silica floc is its conversion from a very large adsorptive floc when first formed, to a compact and dense floc upon slow agitation. This often permits a higher operating rate in upflow clarifier units which rely on sludge blankets. The floc density may likewise stabilize the blanket and retard its overturn.

It has been shown that waters in which substantial pH variations occur respond more uniformly to coagulation involving silica sol addition, than to iron or alum coagulants. The value in low temperature and low turbidity waters has been demonstrated by several investigators (21, 22). A water which had previously been difficult to flocculate because most of the suspended matter was of organic nature improved with the addition of silicate (7).

A new function for silica addition has been revealed at Des Moines, Iowa, where the use of Baylis sol, followed by alum, was instituted under the supervision of C. P. Hoover for the sole purpose of lowering the iron content developed by bacteria during the summer months. Reduction from approximately 0.7 ppm. to 0.1 or 0.15 ppm. was obtained. Fe_2O_3 removal has also proved of interest to chemical plants, textile and paper mills and similar industries.

The application of silica sols in water softening operations is rapidly becoming of paramount importance (5, 6, 14. In waters of low turbidity and low color a reduction or elimination of alum in conjunction with lime softening is indicated. Savings in chemical cost, longer filter runs and improved water have resulted (6).

Successful treatment of sewage with silica coagulation aids has been recorded (23, 24, 25). The tests have shown the combinations with silica are superior to the use of coagulants alone. The advantages parallel those obtained in water treatment.

Criticism of Silicate Treatments

Two somewhat censorious references have appeared in the literature of silica coagulant aids. In one (26), objection is raised to the possibility of an increased SiO_2 content of the treated water, but no substantiating data were provided. For several years analyses at St. Louis (27) have shown that the silicate treatment there does not have a tendency to increase the SiO_2 content in the effluent in comparison with periods when silicate is not used. After careful consideration of SiO_2 residue (14), silica treatment will be employed at the new Chicago plant.

Previous thought attributing an exclusively harmful character to the SiO_2 content of boiler water is not supported by some recent evidence. The form of the silica and its ratio to alkali appear not to have been given proper consideration. The 1 : 3.2 ratio sodium silicate recommended for coagulation falls between the two Philadelphia Quartz Co. grades of which a U.S. Bureau of Mines report (28) states: "These tests indicate that the "S" and "C" brand solutions certainly do not accelerate cracking at 200°C. but tend, on the contrary, to prevent it." Products more alkaline than the "C" brand do give some evidence of being objectionable but are not recommended for coagulation. The methods of preparing the silica sols reduce the normal alkaline character of the sodium silicates.

A large oil company has abandoned its previous efforts to remove silica from a boiler water and is concentrating on Al_2O_3 removal as a means of ending adherent analcite scale.

(*Author's Note:* Since this article was written, Dr. Ralph E. Hall, of the Hall Laboratories, presented a paper before the American Society of Mechanical Engineers in New York City, November 30, 1943, entitled, "A New Approach to the Problem of Conditioning Water for Steam Generation." The introduction of potassium silicates into high-pressure boilers was advocated by Dr. Hall).

The second critical article (22) emphasizes that an acid-treated silica coagulant aid appears deterimental to floc formation with ferric salts and appears limited to conditions of low temperature and low turbidity for the water tested. No exception is taken to to these laboratory studies as restricted to the one water investigated. Such conclusions cannot be generalized, however, in view of the outstanding achievements in Florida (6) where the well waters are always in the temperature range at which these authors state silica additions have little benefit or even detrimental results. Likewise, a maximum of 50 ppm. turbidity would not be substantiated by results at St. Louis and Algiers, La. With the Graf-Schworm method turbidities as high as 8,000 ppm. were successfully coagulated (29).

The difficulty of coagulating ferric salts in the presence of negatively charged colloidal silica was also noted by Baylis (14). It is pointed out by Hazel (13) that colloidal ferric oxide (produced by the ferric salts) is much less effective in discharging silica than is aluminum oxide. At one pH it was found that best precipitation would be obtained from a ratio of about one part Al_2O_3 to 5 parts SiO_2, whereas with Fe_2O_3 the ratio for proper coagulation was one part SiO_2 to 2.3 parts Fe_2O_3. The silica sols used were not strictly comparable to those employed in coagulation aids but may provide an explanation for the results observed. From Hazel's work it is apparent that an excessive amount of silica sol can convert Fe_2O_3 from a positive to a negative colloid. The two colloids then become mutually stabilizing and floc formation is deterred. This emphasizes the necessity of a proper balance between silica and coagulant since alum can also have its charge reversed by silica. Moreover, it demonstrates the possibility of using silica sols as stabilizing agents as well as coagulant aids.

Silica sol preparation involving batch methods and aging is less desirable than continuous methods but this has not materially retarded the use of the silicates. Continuous production processes are being developed and will eventually minimize the mixing and storage problems. In lime softening in Florida, it is apparent that aging the sol to develop large micelles is unnecessary. The density of calcium carbonate is adequate for rapid settling. The action of the negative charge on the silica appears to be the only need. This greatly simplifies continuous sol preparation.

Shortened filter runs occasionally arise from factors in sol preparation which can be corrected. Insufficient dilution of the reacting chemicals or inadequate mixing may produce localized gelation which may then be carried onto the filters. Failure to remove the specified amount of alkali from the silicate may cause cementation of calcium carbonate in the floc or on the

sand grain. At some plants silicate use was abandoned owing to filter difficulties but this is not happening where adequate directions are being followed.

The areas of applicability for silica coagulant aids will become more clearly defined with increased investigation. In certain sections of the country silica treatment has little or no value. Whether this results from inactivation of the silica by unknown constituents of the raw water or from the normal presence of an adequate amount of negative colloids is not clear. In sections where silica has generally proved beneficial, a negative result may indicate improper preparation or dosage.

In many instances greater assurance of success with silica coagulant aids may be obtained through the assistance of a competent consultant or the sodium silicate manufacturer. These sources would also be informed on the most satisfactory equipment to be used in conjunction with the treatment.

Conclusions

After a period of slowly acquired experience the application of silicates for water treatment is showing substantial growth. New methods of preparing silica coagulant aids have been developed and the broad distribution of waters requiring specially prepared silica as an accessory coagulant shows that a truly fundamental advance has been made.

Water treatment is approaching the status of a science. With this achievement there will be a greater challenge to the plant designer and operator to evaluate all meritorious chemical treatments. When such a comprehensive chemical study precedes a decision on new construction it is sometimes found that revised treatment increases the capacity of the existing plant or reduces the cost of new units. Economies may result which will permit available funds to provide added values such as softening, corrosion control, new distribution lines or other services.

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Editor's Note: This article has been carefully considered prior to publication because of its frequent references to patents relating to processes for water treatment. It is the opinion of the Editor that the water works profession is philosophically opposed to the patenting of "processes" for water treatment. It recognizes the propriety of patents for materials and equipment, but it is reluctant to use a method of operation that has been covered by patents.

The following processes relating to the use of sodium silicate in municipal water treatment have been patented:

(1) *Baylis Sol:* U.S. 2,217,466, issued October 8, 1940. For permit write to John R. Baylis, Phys. Chemist, Bur. of Engineering, Dept. of Public Works, Chicago, Ill.

(2) *Graf-Schworm Coagulant:* U.S. 2,234,285, issued March 11, 1941, to A. V. Graf and W. B. Schworm. For permit write to August V. Graf, Chief Chem. Engr., Water Div., Dept. of Public Utilities, St. Louis, Mo.

(3) *N-Sol A:* U.S. patent applied for; *N-Sol B:* U.S. 2,310,009, issued February 2, 1943, to C. L. Baker and C. H. Dedrick. For permit write to the Philadelphia Quartz Co., 121 Third St., Philadelphia 6, Pa.

The above information regarding permits will serve to indicate that any operator of a water treatment plant, who considers the use of silicate of soda, will protect himself and his property by obtaining a permit to use whichever process interests him.

The Concentrations of Certain Trace Metals in Drinking Water

By Robert A. Kehoe, Jacob Cholak and Edward J. Largent

CERTAIN observed effects upon the public health, produced by the presence of a number of inorganic substances in public water supplies, have served as the basis for establishing permissible limits for the concentration of these elements in drinking water (1, 2, 3, 4). Since no data are readily available which will show how the usual water supply meets these safety requirements, an analytical survey was made of the current water supplies of a number of communities in the eastern and central portions of the United States. In addition, data have been collected from the literature on the ranges of concentration of many elements in various types of natural waters, the elements being divided into groups under the classification adopted by Calvery (5), and the data, collected from various references in Chemical Abstracts (6), Mellor (7) and Clarke's "Data of Geochemistry" (8), are given in Tables 1, 2 and 3. In many instances the extremes which have been reported are not shown here; nevertheless, the tables demonstrate the wide compositional differences which occur in nature. Many of the waters upon which these results were obtained would hardly be used for drinking purposes by either man or beast because of their salinity, acidity or odor.

Water samples were collected at random from domestic, industrial and other water supplies derived from surface and well waters. These samples may be regarded as representative of the drinking water used by a large proportion of the American population. At the same time they portray the composite effects of the current method of treating and distributing community water supplies. The concentrations of various metals in these waters are given in Table 4. The mean values, and also the permissible limits, are given to show how the usual supply meets the accepted standards for drinking water.

In each case a 1-gal. sample of water was taken, if possible, from a tap that had been permitted to run freely for 5 min. Since, from the standpoint of consumption, the metal content whether suspended or dissolved was important, well-shaken unfiltered samples were removed for analysis. The sample (1 liter) was acidified with 1–2 ml. of concentrated nitric acid, evaporated almost to dryness and then rinsed into glass-stoppered 25-ml. graduated Pyrex cylinders, sufficient double-distilled

A contribution of the Kettering Laboratory of Applied Physiology, College of Medicine, University of Cincinnati, Cincinnati, Ohio.

TABLE 1

Concentrations of Nutritive Trace Elements in Natural Waters
Milligrams of Element per Liter of Water (6, 7, 8)

Element	Surface Water	Ground Water	Sea Water
Iron	Trace–11.0	Trace–400	0.002–0.28
Manganese	0.003–1.41	Trace–64	0.001–0.011
Zinc	Nil–0.036	Nil–120	0.001–<0.01
Copper	Nil–0.068	Nil–12.0	0.003–0.09
Iodine	0.0001–0.032	Nil–50.0	0.02–2.0
Cobalt	<0.0001	Nil–14.0	Trace

TABLE 2

Concentrations of Non-nutritive Non-toxic Trace Elements in Natural Waters
Milligrams of Element per Liter of Water (6, 7, 8)

Element	Surface Water	Ground Water	Sea Water
Aluminum	Trace–18.5	Trace–740	0.54
Boron	Nil–650	Trace–1000	4.5–4.75
Chromium	———	Nil–0.04	———
Silicon	Trace–110	Trace–150	0.02–2.1
Tin	Nil–Trace	Nil–Trace	———
Titanium	Nil–0.055	Nil–Trace	Trace
Nickel	Nil–0.02	Nil–33	0.0001–0.01
Strontium	Nil–1.65	Nil–3420	Trace

TABLE 3

Concentrations of Non-nutritive Toxic-toxic Trace Elements in Natural Waters
Milligrams of Element per Liter of Water (6, 7, 8)

Element	Surface Water	Ground Water	Sea Water
Silver	Nil–Trace	Nil–Trace	0.01 –0.25
Lead	0.001–0.004	0.001–0.06	0.001–0.008
Arsenic	Nil–80	Nil–85	0.001–0.08
Mercury	Nil–0.0005	Nil–Trace	———
Fluorine	0.001–3.2	0.001–23	0.30 –0.90
Selenium	Nil–2.5	Nil–1600	<0.0003
Barium	———	Nil–410	Trace
Cadmium	———	Nil–0.55	———
Bromine	Nil–30.0	Nil–1600	42–83
Antimony	Nil–Trace	Nil–0.56	Trace
Thallium	———	Nil–Trace	———
Molybdenum	———	Nil–270	0.0001–0.0005
Vanadium	Nil–Trace	Nil–0.98	0.00015–0.0003
Bismuth	———	Nil–Trace	———

TABLE 4

Concentrations of Certain Metals Found in the Drinking Water of Various Localities in the U.S. Milligrams of Element per Liter of Water

City	Mn	Pb	Fe	Al	Cu	Zn	As	F
Boston, Mass.	0.025	0.005	0.09	0.01	0.065	Nil	Nil	0.08
Fall River, Mass.	0.025	0.025	0.08	0.005	0.58	0.03	Nil	0.10
Providence, R.I.	0.006	0.003	0.40	0.015	0.006	0.03	0.003	0.10
Montclair, N.J.	0.015	0.008	0.06	0.012	0.03	0.30	Nil	0.11
Manhattan, N.Y.	0.01	0.015	0.02	0.015	0.04	0.11	Nil	0.04
Rochester, N.Y.	0.002	0.004	0.03	0.05	0.20	0.002	Nil	—
Baltimore 1, Md.	0.023	0.011	0.03	0.035	0.025	0.06	Nil	0.13
Baltimore 3, Md.	0.005	0.003	0.02	0.011	0.05	0.02	0.006	0.07
Atlanta, Ga.	0.004	0.009	0.015	0.01	0.02	0.03	Nil	0.07
Hopeville, Ga.	0.24	0.009	0.035	0.04	0.02	0.19	Nil	—
Albany, Ga.	0.01	0.005	0.023	0.01	0.02	0.09	Nil	0.24
Birmingham, Ala.	0.004	0.003	0.06	0.13	0.035	0.03	0.003	0.15
Cleveland, Ohio	0.013	0.005	0.13	0.07	0.045	0.07	0.003	0.02
Kent, Ohio	0.008	0.008	0.035	0.07	0.02	0.04	0.006	1.60
Lima, Ohio	0.035	0.016	0.19	0.015	0.03	0.02	Nil	1.70
Toledo, Ohio	0.025	0.008	0.13	0.03	0.035	0.86	Nil	0.11
Columbus, Ohio	0.003	0.01	0.02	0.015	0.015	0.05	Nil	0.19
Springfield, Ohio	0.008	0.018	0.07	0.015	0.03	0.05	Nil	0.25
Dayton, Ohio	0.07	0.001	0.19	0.03	0.05	0.32	Nil	0.24
Oakwood, Ohio	0.023	0.015	0.10	0.02	0.20	0.40	Nil	0.18
Cincinnati, Ohio	0.01	0.01	0.40	0.10	0.03	0.015	0.008	0.20
Louisville, Ky.	0.025	0.04	0.13	0.09	0.03	0.02	Nil	0.15
Chicago, Ill.	0.002	0.006	0.04	0.01	0.01	0.06	Nil	0.13
Arlington Hgts., Ill.	0.045	0.025	1.12	0.005	0.05	0.21	Nil	0.81
Detroit, Mich.	0.005	0.006	0.035	0.28	0.05	0.13	Nil	0.08
Birmingham, Mich.	0.028	0.005	2.50	0.01	0.02	0.05	Nil	0.95
Pontiac, Mich.	0.011	0.008	2.50	0.01	0.015	0.25	Nil	0.71
Ann Arbor, Mich.	0.008	0.005	0.025	0.011	0.025	0.05	Nil	0.39
Minneapolis, Minn.	0.01	0.005	0.04	0.80	0.025	Nil	Nil	0.12
Milwaukee, Wis.	0.01	0.008	0.07	0.10	0.035	0.12	Nil	0.13
Kansas City, Mo.	0.004	0.003	0.02	0.27	0.03	0.01	Nil	0.34
N. Kansas City, Mo.	0.21	0.019	0.90	0.09	0.025	0.04	0.002	0.37
Weston, Mo.	0.004	0.003	0.015	0.005	0.015	0.01	Nil	0.28
Wichita, Kan.	0.025	0.005	0.04	0.01	0.02	0.04	Nil	0.43
Tulsa, Okla.	0.005	0.013	0.02	0.013	0.05	0.48	Nil	0.04
Sapulpa, Okla.	0.023	0.005	0.19	0.013	0.023	0.16	Nil	0.14
Bristow, Okla.	0.02	0.025	0.05	0.013	0.035	0.11	Nil	0.20
Mean	0.017	0.011	0.300	0.091	0.059	0.136	0.001	0.317
U.S.P.H.S. Standard	0.30*	0.10	0.30*	—	3.0	15.0	0.05	1.0

* Mn and Fe combined.

Note: Sn, Ag and Hg absent except as follows: Sn, Atlanta, Ga., and Hopeville, Ga., 0.001; Hg, Lima, Ohio, 0.001.

TABLE 5

Sources of Water, Chemical Treatment, and Nature of Piping From Which Samples (Table 4) Were Taken

Location	Source of Water	Chemical Treatment	Nature of City Mains and Piping in Buildings Where Drawn
Boston, Mass.	Surface (reservoirs)	None except chlorination	Iron, transite; galvanized iron, copper and lead
Fall River, Mass.			Cast iron; brass and galvanized iron
Providence, R.I.	Reservoir at Sciterate, R.I.		
Montclair, N.J.	Wanaque Res.	Chlorine, ammonia + sodium hexametaphosphate	Steel, cast iron, galvanized iron
Manhattan, N.Y.	Ashokan and Scholarie Res.	Copper sulfate (periodic) Alum, chlorine, aeration	Steel, cast iron; steel and cast iron
Rochester, N.Y.			Cast iron, brass
Baltimore 1, Md.	Gunpowder Falls	Alum, lime (iron sulfate seasonally), chlorine?	Concrete, cast iron, galvanized steel, brass
Baltimore 3, Md.	Spring (Herring Run Park)	None	Steel
Atlanta, Ga.	Chattahoochee R.	Alum, chlorine, ammonia calcium hydrate + carbon	Cast iron, brass
Hopeville, Ga.	Well (26 ft. deep)	None	Galvanized pail
Albany, Ga.	Wells (1,000–10,000 ft. deep)	Chlorine, ammonia	Cast iron, galvanized iron, brass
Birmingham, Ala.	Kahala R., Lake Purdy	Alum, lime, chlorine, ammonia	Cast iron, cement lines, galvanized iron, copper, brass
Cleveland, Ohio	Lake Erie	Lime, soda, chlorine	Cast iron, lead lead in pipes, wrought iron, brass
Kent, Ohio	Artesian wells	Lime, soda	Cast iron, lead lead in pipes, wrought iron, brass
Lima, Ohio (Oil Refinery)	Well (150 ft. deep)	None	Cast iron
Toledo, Ohio	Lake Erie	Alum, lime	Cast iron
Columbus, Ohio	Scioto R.	Alum, lime, soda ash, chlorine hexametaphosphate	Cast iron, galvanized iron
Springfield, Ohio	Surface and well	Chlorine	Cast iron, galvanized iron, steel
Dayton, Ohio	Wells (100 ft. deep)	Chlorine	Cast iron, brass
Oakwood, Ohio	Wells (100–125 ft. deep)	Chlorine	
Cincinnati, Ohio	Ohio R.	Iron sulfate, lime, chlorine, ammonia	Cast iron, galvanized iron
Louisville, Ky.	Ohio R.	Iron sulfate, lime, chlorine	Cast iron, galvanized iron
Chicago, Ill.	Lake Michigan	Chlorination, ammonia-chlorine	Cast iron
Arlington Hgts., Ill.	Well water	None	Cast iron, lead lead in pipes, lead
Detroit, Mich.	Lake St. Clair	Alum sulfate when required, chlorine and ammonium sulfate	Cast iron, copper, brass
Birmingham, Mich.	Ordinary wells	None	Cast iron, lead lead in pipes, galvanized iron
Pontiac, Mich.	Driven wells (200 ft. deep)	None, except half is chlorinated	Cast iron, galvanized iron
Ann Arbor, Mich.	Wells and river water	Lime, soda	Cast iron, brass
Minneapolis, Minn.	Mississippi R.	Chlorinated, soda ash, lime, chlorine	Cast iron, copper lead in line, cast iron
Milwaukee, Wis.	Lake Michigan	Alum, lime, carbon, chlorine	Cast iron, galvanized iron
Kansas City, Mo.	Missouri R.	Alum, lime, soda ash	Cast iron, galvanized pipe
N. Kansas City, Mo.	Deep wells	Alum, lime	
Weston, Mo.	Lime spring water	None	Galvanized pipe
Wichita, Kan.	Wells 22 mi. from city	Lime, alum, ferrous sulfate, chlorine, ammonia hexametaphosphate	Cast iron (concrete lined), galvanized iron
Tulsa, Okla.	Spavinaw Lake	Alum, lime, chlorine	Concrete, cast iron, galvanized iron, steel
Sapulpa, Okla.	Lake water	Iron, sulfate, lime, chlorine	Cast iron, galvanized iron lead in pipe, galvanized iron
Bristow, Okla.	Deep wells	None except chlorine	Cast iron, galvanized iron lead in pipe, galvanized iron

water being added to make the volume 25 ml. If necessary, more acid was added to dissolve precipitated salts before final adjustment of the volume. A portion of the prepared sample was analyzed spectrographically for manganese, lead, tin, iron, aluminum, copper and silver (9, 10, 11). Other aliquots corresponding to 200-ml. portions of water were analyzed separately for zinc, arsenic and mercury. Arsenic was determined by the Bambach polarographic method (12), mercury by the di-β-naphthylthiocarbazone extraction procedure reported by Hubbard (13) and zinc by a recently developed extraction and polarographic procedure (14). A separate portion, 250 ml. or more, of each water sample was employed for the determination of fluorine after the addition of magnesium acetate (15), evaporation and ashing. The fluorine was separated from the ash by the Willard and Winter distillation method (16), employing steam instead of water (17) and with the addition of silver sulfate (18) to prevent distillation of chlorides as hydrochloric acid. The Dahle (19) back-titration method was used for the estimation of fluorine in the distillate.

The sensitivities of the analytical procedures were such that as little as 0.001 mg. of metal per liter could be determined in the case of all metals except silver and fluorine. In the case of silver, as little as 0.0005 mg. per liter could be determined, while 0.02 mg. fluorine per liter had to be present for accurate estimation.

Table 5 gives the origin of the water, the type of water treatment employed and the composition of the piping system in use.

As it is also of interest to know how the concentration of certain metals varies with the length of storage of water in the pipes, a number of water samples were taken from the same tap at various intervals following all-night storage. The results for samples obtained from a cold and a hot water line, respectively, are given in Tables 6 and 7.

From the data of Table 4 it may be seen that the mean values for all the metals except iron are well below the accepted safe limits. In the case of

TABLE 6

Variations in Concentration of Metals in Cold Water Drawn From the Same Tap at Different Times and Under Different Conditions*
Mg. Metal per Liter

Metal	6-26-43	7-1-43			7-7-43		
	10-min. Running	First Flow	10-min. Running	1-hr. Running	First Flow	10-min. Running	1-hr. Running
Mn	0.01	0.005	0.002	0.028	0.028	0.025	0.020
Pb	0.01	0.01	0.001	0.01	0.005	0.010	0.010
Fe	0.40	0.23	0.02	1.60	0.50	0.54	0.22
Al	0.10	0.025	0.002	0.090	0.33	0.20	0.045
Cu	0.03	0.11	0.02	0.03	0.03	0.025	0.030
As	0.008	0.003	Nil	0.003	Nil	Nil	Nil
Zn	0.015	0.090	0.030	0.070	0.020	0.110	0.030

* Galvanized iron line, copper valve and tap.
Sn, Hg, Ag = nil.

iron, the mean value reaches the permissible limit, but this is due to the inclusion of the high iron findings in a few individual water samples. The majority of the samples contained quantities of iron and manganese well below the combined limit set for the two metals. It is not to be inferred that all of the iron was in actual solution, since practically all the samples of high iron content were slightly turbid and colored. It is likely that in respect to iron content, these waters are not representative of the supply for the entire community. This is probably a local condition arising from the state of the particular domestic piping system from which the samples were obtained. It is entirely likely that the iron content of such waters would be appreciably lower if sampling were done after the water had been allowed to run from the tap for a considerably longer period than that set up as the standard sampling procedure in this study.

It is also evident from the tables that the use of certain compounds, particularly those of aluminum and iron, as coagulating agents, does not tend to increase the concentration of these metals in purified waters. When the water leaves the purification plant, these metals are frequently present in considerably lower concentrations than before the treatment.

It will also be observed that the mean value for fluorine in the water of the region studied is well below the accepted safe limit. The two values which are markedly above the limit are for well waters in the Lima-Kent area where mild dental fluorosis is known to be endemic.

The wide use of copper, brass, lead and galvanized piping to deliver water did not appear to introduce hazardous quantities of lead, copper or zinc into the waters studied as is indicated by Table 5. In only a very few instances were traces of tin, mercury or arsenic found, while silver was either absent or present in amounts not exceeding 0.0005 mg. per liter.

In the experiment dealing with the effects of length of storage on the metal concentrations of the waters (Tables 6, 7), the greatest variations

TABLE 7

Variations in Concentration of Metals in Hot Water Drawn From the Same Tap at Different Times and Under Different Conditions*
Mg. Metal per Liter

Metal	7-1-43	7-7-43	
	10-min. Running	First Flow	10-min. Running
Mn	0.001	0.008	0.018
Pb	0.010	0.016	0.010
Fe	0.115	0.40	0.95
Al	0.070	0.025	0.030
Cu	0.030	0.06	0.060
Zn	0.090	0.140	0.020

* Copper line, tap and valves.
Sn, Ag, As, Hg = nil.

were obtained in the case of iron, zinc and aluminum, in the order given. The concentration of copper in the water from the hot water line was only slightly higher than that from the cold water tap, where the only source of copper was the tap itself. Again the increased concentration of iron was associated with an increased turbidity and color. In one case (Table 7) the iron content increased as the water was allowed to issue freely from the tap. This was evidently due to a local disturbance in the main at a spot some distance from the tap.

Braidech and Emery, in 1935, reported an exhaustive spectrographic study of the minor chemical constituents present in various water supplies in the United States (20), and their work is of special interest because of the many elements studied. Their material consisted of composite daily samples, collected over a period of two months, from 24 municipal purification plants. The spectrographic examinations were made with the dried residues obtained following evaporation of 2-liter samples. Although their figures are based on the use of a semi-quantitative analytical method, their findings, except those for zinc, fluorine and silver, are in general agreement with ours. Our results for zinc and fluorine are somewhat higher and those for silver are considerably lower than the figures reported by Braidech and Emery. These investigators show no results for mercury or arsenic, but they have included many other elements not given in our tables. Of interest is their report that boron, strontium and barium were consistently present in all waters which they examined, and that nickel, chromium and titanium were present in most. In some waters they also detected traces of lithium, molybdenum, vanadium and cobalt.

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War Contracts Price Adjustment Board

According to a release from the OWI (NB–2490) dated May 11, 1944, the War Contracts Price Adjustment Board on May 10, approved regulations covering the exemption from renegotiation of certain classes and types of public utility contracts and subcontracts and prescribed the form of mandatory financial statement to be filed by public utility companies subject to the 1943 Renegotiation Act. This announcement was made by the War Contracts Price Adjustment Board on May 11.

Public utility and steamship operating companies are not required to file the Standard Form of Contractor's Report, but must file, in order to comply with the mandatory filing provision, subsection (c)(5)(A), of the act, an appropriate statement containing the following information:

Name and address of contractor.

Names of companies, if any, under the control of, or controlling, or under common control with the Contractor.

Nature of principal business.

Date of expiration of fiscal year.

Balance sheet, profit and loss statement and surplus statement of the contractor for latest completed fiscal year.

Declaration by the contractor that it will furnish such further and additional information as may be required by or on behalf of the War Contracts Board.

The board emphasized that all war contractors subject to negotiation with respect to their fiscal years ending after June 30, 1943, and before March 1, 1944, are required by law to file in duplicate the prescribed mandatory financial statement on or before June 1, 1944, with the War Contracts Price Adjustment Board, Assignments and Statistics Branch, Renegotiation Division, Room 3 D 573, The Pentagon, Washington 25, D.C., or the department or service to which the contractor has been assigned.

The Hygienic Significance of the Contamination of Water With Certain Mineral Constituents

By Robert A. Kehoe, Jacob Cholak and Edward J. Largent

THE physiological effect of the continued ingestion of small amounts of certain elements present in food or drinking water has been the subject of considerable investigation. On the basis of such studies, allowable limits of concentration in drinking water have been suggested for a number of the more toxic elements (1, 2, 3, 4). Existing standards will probably be revised, however, as knowledge of the occurrence and physiological action of these elements progresses. The occurrence of certain elements in the water supplies of many communities of eastern and central United States has been reported elsewhere (5). This paper will concern itself, therefore, only with hygienic significance.

The elements will be considered in groups under the same classification as that adopted by Calvery (6): (1) "nutritive trace elements" which are necessary to the normal biological processes of man and the higher animals; (2) "non-nutritive non-toxic trace elements" which are not harmful to man or higher forms of animals when present in the diet in quantities not exceeding 100 ppm.; and (3) "non-nutritive toxic trace elements" which are known to be harmful to higher forms of animal life when less than 100 ppm. is incorporated into the diet.

Despite the present usefulness and convenience of this classification, it should be borne in mind that further investigation may show that certain of the elements classified in groups 2 and 3 belong in group 1.

Pharmacology of the Trace Elements

1. *Nutritive Trace Elements (Iron, Manganese, Zinc, Copper, Iodine, Cobalt)*

All the elements in this group except cobalt have been found to be necessary to human nutrition and cobalt is known to be required by certain animals. The amounts of these elements obtained by man from drinking water are very small as compared to those required. They are also much smaller than those obtained by man from foods, especially those of vegetable origin.

Iron: Since iron is present in the body to the extent of 3.0 to 3.5 g., it can hardly be classed as a trace element, but it has been included in this discussion because of the small amounts usually found in drinking water and the care taken to remove it. Iron,

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taken in reasonable amounts, is nontoxic, except as it is injected intravenously, when its effects resemble those of arsenic (7). When administered in this fashion, toxic effects are produced by doses as low as 60 mg. per kg. of body weight. It has been estimated that the body requires 6–12 mg. of iron daily, while the mean daily intake from food is 19 mg. (8). Iron in water, therefore, is not important physiologically in meeting the iron requirement. Limits have been set for this metal but these are of significance only in relation to the appearance and taste of the water. The earlier standard of 0.3 ppm. (3) has recently been revised; according to present standards, this value should not be exceeded by the combined iron and manganese content (4). This revision apparently was made, however, for other than physiological reasons.

Manganese: Manganese, like iron, is removed from water for other than physiological reasons. No harmful effects have been observed from the use of water containing iron and manganese in amounts up to 0.5 ppm. (9), and only one reference to illness attributed to manganese in water was found (10). This was in Japan where 16 persons were said to have been poisoned (3 fatally) by drinking well water containing considerable quantities of manganese (and zinc). Chronic manganese poisoning, however, does result from the inhalation of manganese compounds in mining and grinding operations (11). The chief symptoms are nervousness with mental and ataxic disturbances (7, 11). While manganese is thought to play some part in the metabolism of man and animals (12, 13), the amount required daily has not been established. The daily requirement is probably very low —the normal American diet contains about 4 mg. per day, mostly in foods of vegetable origin (14).

Zinc: The earlier limit of 5 ppm. of zinc in water (3) has been revised, the present limit being 15 ppm. (4). That such a revision was justified and that the limit set may yet be too strict, has been proved by the work of a number of investigators. Consumers' experience with water containing as much as 40 ppm. has shown that this concentration is harmless (15), although zinc imparts a milky appearance to water when present in amounts of 30 ppm. (16) and a metallic taste when 40 ppm. are present (15). Bartow and Weigle (17) administered water containing 1,000 ppm. of zinc to rats for 40 days and observed no toxic effects other than occasional nervousness, which appeared particularly on hot days. Heller and Burke (18) found no abnormalities in the organs of rats fed a ration to which zinc was added as zinc dust, zinc oxide or other zinc compounds, in amounts as great as are found in contaminated foods. Negus (19), however, advises against the use of waters containing relatively high amounts of zinc in making acid drinks, because of the possible formation of poisonous organic zinc compounds such as zinc citrate. Evidently the radicle combined with the zinc governs the degree of toxicity of zinc. Drinker and Fairhall (16) list the compounds in the following order, in respect to their irritating properties and causticity: chloride, sulfate, acetate, lactate, tartrate and malate.

Copper: Late in 1942 the U. S. Public Health Service Committee on Water Standards raised the permissible concentration of copper in drinking water to 3 ppm. (4) as compared to the earlier limit of 0.2 ppm. (3). This revi-

sion seems to be in line with European practice. In Holland, drinking water is considered safe if, after standing for 16 hr. in a new copper line, it does not contain more than 3 ppm. copper, and if, after flowing freely from the tap, it contains not more than 2 ppm. (20).

Copper is essential for man and the higher animals (12, 21, 22) and it is estimated that man requires about 2 mg. of copper daily. Since the mean daily intake from food is only 2.2 mg. (14), small amounts in water may be helpful in insuring an adequate intake. Copper imparts some taste to water but individuals evidently vary in the acuity of their taste perception, for values of 1.5 ppm. (23), 2 ppm. (24), and 5 ppm. (25) have been variously reported as the limits above which taste is affected. Py (26), in a study of French waters, found a normal value of 0.5 mg. Cu per liter, with some containing as much as 5 mg. per liter. He believes that the latter quantity is not harmful since ingested copper is absorbed by pulpy foods and is eliminated. A practical equivalence between intake and output has been shown by Kehoe, *et al.* (14).

Large amounts of copper salts injure the mucous membrane of the alimentary canal, but, generally speaking, the toxicity of copper salts for complex animal organisms is low, while their absorption is quite limited (7). Copper salts have an emetic action and therefore it is difficult to retain in the system amounts sufficient to cause acute illness. Calvery (6) has voiced an opinion that is shared by others, that the chronic toxicity of copper has been incompletely investigated and that further investigation is necessary.

Chronic copper deficiency in cattle has been studied by Bennetts (27), who found that cattle do badly when the herbage contains only 2–4 ppm. copper, and that copper supplements fed to cattle or applied to the grazing land are effective in bringing about complete cure. When the herbage contains only 1–2 ppm. copper (28), cattle suffer from an illness called "falling disease" and may die very suddenly. Horses, sheep and pigs are said not to be affected by acute "falling disease" (22).

Copper may find its way into water supplies from the use of copper and brass pipes, soft waters with a low carbon-dioxide content being especially aggressive in attacking this metal. Another possible source is copper sulfate when used as an algaecide, but the amount entering in this way is far less than that taken from copper or brass distributing lines. It is thought that the ammonia-chlorine-copper sulfate treatment of water prevents the precipitation of copper carbonate and secures more prolonged algaecidal action without increasing the hazard to the consumer. In any event no case of copper poisoning from a purified water supply has been proved (19).

Iodine: The physiological effects of the complete lack of iodine are well known. Although data on balance studies are too few to show the normal daily requirement, indications are that it is low, possibly 0.05–0.10 mg. (29). This amount may be supplied by foods and drinking water, but the quantities present are so variable that it is often necessary to add iodine to the diet. The amount found in drinking water usually is too small to be a significant factor in meeting the daily requirement, but the iodine present in the water supply appears to be the principal determinant of the iodine content

of soil and vegetation in any area. Iodine is not added to American water supplies, although at one time this was done at Rochester, N.Y. (30). Many people are known to be hypersensitive to this element, and deficiencies are usually made up by proper medication under a physician's care. (Iodized table salt is now generally available in the United States and is probably widely used by persons who have no medical advice concerning the matter.)

Cobalt: Cobalt seems to be necessary for the normal nutrition of some animals (12, 29), but there is no convincing evidence of its need by man. The quantities of cobalt found in biological materials and water generally are so small that its ingestion in amounts exceeding traces in food and drink is extremely unlikely. What is more, it has been shown that when cobalt is ingested, very little is retained, 90 per cent being eliminated within 2 days (31). The addition of cobalt to the diet causes polycythemia. It has been shown that 0.04–0.05 mg. of cobalt (the amount present in the entire carcass) was sufficient to produce a marked polycythemia in a rat (32). Insufficient quantities of cobalt in the forage of sheep produces enzoötic marasmus or "bush sickness" known in Scotland as "pining." McNaught and Paul (33) report that this sickness is prevalent among sheep grazing upon vegetation which has a cobalt content of 0.005–0.17 ppm. dry matter. Healthy pastures contain 0.04–0.37 ppm. but the amount varies with the season. The application of a cobalt-containing dressing upon pasture lands deficient in this element is reported to have produced highly satisfactory results in the sheep that later grazed there.

2. *Non-Nutritive, Non-Toxic Trace Elements (Aluminum, Tin, Silicon, Boron, Chromium, Titanium, Nickel, Strontium)*

None of the elements in this group is known to play any part in human nutrition, although some are so widely distributed in nature that they may eventually be found to be essential for the biological processes of some forms of life. In most cases, their toxic oral doses are so high that their presence in drinking water generally is not of physiological significance.

Aluminum: Most of the aluminum in the human diet arises from the use of aluminum cooking utensils and baking powders containing aluminum compounds. The diet of some North Americans contains as much as 3 g. of aluminum per week (29), but apparently none is absorbed, practically all of it being eliminated with the feces (14, 34). Our experimental observations, in which as much as 300 mg. aluminum was ingested daily by a human subject over a period of months, failed to demonstrate any evidence of the alimentary absorption of aluminum, or any indication of harmful effects (34). Large amounts of aluminum salts in the diet over a sufficient period of time are capable of causing rickets (35), an effect presumably due to interference with the absorption of phosphorus (36).

Aluminum may find its way into drinking water principally from the use of aluminum storage vessels and as a residuum following the use of aluminum compounds in water purification plants. The amounts retained in water following coagulation procedures, however, are so small that only the most sensitive microchemical methods will reveal their presence. Frequently the

quantity present in purified water is less than the amount contained before treatment.

Tin: Small amounts of tin may be discovered in drinking waters which are stored in tin-coated metal containers or distributed through tin-coated or galvanized lines. The amounts, however, rarely exceed a few hundredths of a milligram per liter, while the normal mean intake from the American diet approximates 20 mg. per day (14). The amount ingested daily is extremely variable and depends on the diet, principally on the amount of canned food used by the individual. All of the ingested tin is excreted in the feces (14). Recent observations, carried out in this laboratory on a number of workmen exposed to tin fumes in foundries, have failed to show significant absorption of tin as measured by the concentration of tin in the blood and urine of the workmen. However, analyses of the tissues of a man exposed for many years to metal fumes in a brass foundry (not involved in the foregoing observations) showed the presence of tin in measurable quantities and demonstrated that absorption can occur following the inhalation of this element.

Silicon: There is no evidence that silicon is toxic when ingested, although when inhaled as finely divided free silica, its effects are well known. Silicon occurs in all plant life and is therefore part of the intake of all animals. It has been detected in all human tissues (37, 38) and following its ingestion, its concentration in the blood remains elevated for several weeks (38). Silicon undoubtedly is absorbed, as is evident from its excretion in the urine, but most of that which is ingested is evacuated in the feces (29).

Boron: The presence of boron in the water supply is a regional phenomenon, and so far as is known, it does not offer a public health problem. Small amounts have been detected in drinking waters but as much as 30 ppm. is permissible (1, 2).

Other Elements: Of the remaining elements in this group none except chromium is likely to be encountered in drinking water in more than scant traces and, therefore, these elements do not constitute a health problem.

Chromium must be considered here because its compounds may be added to water to serve as anticorrosive agents. A proprietary preparation is now on the market which is to be added to water in amounts to give 0.1 ppm. of chromium (19). The physiological effects of the continual use of such waters have not been determined, but according to the 1942 Water Standards (4) the presence of hexavalent chromium in drinking water is not permissible. Hexavalent chromium is much more toxic than trivalent but both forms have a corrosive action on the intestinal tract and on the skin (7). Analyses have shown that chromium is present in dairy milk in concentrations up to 0.5 ppm. (39). Investigation of the toxicity of chromium lactate added to the diet of rats revealed that it is promptly and completely eliminated and that 100 ppm. in the diet had no deleterious effect on the general health and reproductive capacity of these animals (39).

3. *Non-Nutritive Toxic Trace Elements (Lead, Fluorine, Selenium, Arsenic, Bromine, Silver, Barium, etc.)*

These elements form the largest group to be considered in this discussion. Since many of them are so widely distributed in nature, it would not be remarkable if evidence were to

be obtained eventually that their presence in traces is of biological importance. None has yet been shown to be necessary to man, while their ingestion in sufficient quantities is accompanied by well-defined toxic effects.

Lead: The mean daily lead intake of the average North American adult is about 0.3 mg. of lead in food and beverages, and quantities of this order of magnitude are eliminated daily (40, 41, 42). The alimentary absorption of lead is slow and ineffectual but some regular absorption occurs, this being offset by that excreted (in the urine) so long as the mean quantity ingested daily is within or not much in excess of the normal limits. When ingested in amounts of 1.3 mg. or more per day, lead is absorbed in greater amounts than can be excreted, and a portion of the absorbed lead is retained in the body (42, 43). The exact level of oral intake at which progressive retention occurs has not been established, but it is somewhat in excess of 0.3 mg. per day and less than 1 mg. per day. Daily determinations of the total lead intake and output of a young healthy man, to whose normally chosen diet (containing the mean daily quantity of 0.34 mg. lead) was added 1 mg. of soluble lead daily over a period of 3½ yr., demonstrated that a slight but regular retention of lead occurred without change in the general health or well being of the subject. There was a progressive increase in the lead concentration of the blood and the urine of this subject and at the end of the period of ingestion the concentrations in these were well above normal. It appears, therefore, that such a quantity of soluble lead could not be taken for an indefinite period with safety. Another subject, given 2 mg. of lead per day (in addition to the 0.31 mg. [mean value] that occurred daily in his food) for more than a year showed a proportionately greater rate of absorption and retention (than that of the subject given 1 mg. per day), while still another given 3 mg. per day above that in his diet over a period of 4 mo., absorbed and retained lead at a still more rapid rate. The concentrations of lead in the blood and urine of the latter two subjects were approaching potentially dangerous levels (in terms of industrial experience) when the abnormal lead intake was terminated.

One conclusion drawn from these observations is that there is a sufficient factor of safety in the lead content of the food materials in general use in the United States. However, this safety factor may be altered appreciably if the lead in drinking water is at a high level. One European authority sets the safe level for lead in drinking water at 0.3 ppm (44). It is now apparent that such a standard is inadequate for more than brief periods of time. In this connection it is important to reckon with the daily consumption of water for beverage purposes as well as that used in cooking and in washing dishes and cooking utensils. The limit of 0.10 ppm. lead has been set by the U.S. Public Health Service (4), and above this level a water supply may be rejected for drinking purposes. This limit in general is not hard to meet and to maintain, especially since the lead content of water is normally very low. This standard appears to be satisfactory, except under unusual conditions that require greatly increased water consumption over long periods of time.

The danger in the use of lead connecting lines in domestic water distribution systems is generally recognized but in many cities this has little sig-

nificance (5). When lead pipes are present in the distribution system, the lead content of the water may reach high levels, depending on the pH, CO_2 and salt content of the water. Many reports of lead poisoning from such water supplies are recorded in the literature. Epidemics of lead poisoning traced directly to the water supplies have occurred, among other places, in New England (45), Germany (46), Great Britain (47) and France (48). The water that caused the poisoning in Germany contained 55 mg. of lead per liter, and that in Great Britain 7 ppm. In New England the highest concentration of lead in the water was 0.71 mg. per liter, and poisoning is said to have occurred in 14 persons who ingested as little as 0.10 mg. lead daily, over an average period of 8¼ yr. In view of the experimental observations on human subjects referred to above, and taking into account the technical difficulties of sampling and analyzing water so as to establish the dosage, it seems probable that these individuals had considerably greater lead exposure than that represented by the ingestion of 0.1 mg. per day.

Greenburg (49) and Höll (50) cite instances in which contamination of rain waters used for drinking purposes resulted in several cases of lead poisoning. Höll studied the distribution system of Helgoland Island and found as much as 6 mg. lead per liter in water which was piped to the consumer through lead distribution lines. In the supply studied by Greenburg, lead entered the water from the lead flashing on the roof which was used to catch the rain water.

Thouvenet (48) reports finding 150 cases of lead poisoning, some grave, in a French city where short lead pipes were used to tie in domestic lines with the city's cast-iron mains. He found the danger of poisoning to be greatest when the lines were new and when the water contained little calcium carbonate. When old, the lead pipes are less dangerous since they become covered with a protective coating of insoluble salts.

Another source of contamination—one that is much more widely distributed than lead pipe—lies in the almost universal use of compounds of high lead content in luting the joints of pipelines. In new buildings these compounds continue to release lead into the water supply for an appreciable period of time. Kehoe, Thamann and Cholak (40) investigated the water supply in a new building and found 0.37 to 0.92 mg. lead per liter after the water had been permitted to stand in the pipes for variable periods of time. When the water was analyzed after having been allowed to run freely from the taps for 15 min., only 0.03 mg. lead was found, and after running 1 hr., no lead was demonstrable with the analytical method then in use. After the luting compounds have aged, very little lead enters the water.

Fluorine: The subject of fluorine in water has received considerable attention. Its presence in drinking water is a matter of regional importance in connection with the problem of mottled enamel in at least 25 states (51, 52). Mottled enamel of the teeth of children occurs when water contains 0.9 mg. per liter or more; a 75–80 per cent incidence is found when the fluorine content is 2.5 mg. per liter, and at 6 mg. per liter the incidence is 100 per cent (53, 54). Fluorine is widely distributed in nature and is present in practically all biological material, foods containing on an average approximately 0.8 ppm. (55). Comparison of

foodstuffs obtained in areas where mottled enamel is not found, with those grown in regions in which mottled enamel is endemic, indicates that the small amount of fluorine found in food plays but a small part in the production of mottled enamel (52). This is further verified by the experience of the inhabitants of Bauxite, Ark., where the incidence of mottled enamel in children was sharply reduced merely by changing the water supply from deep wells containing 14 ppm. fluoride to the Saline River which was practically free of fluorine (56).

Machle and Largent (57, 58) studied the absorption and excretion of fluorides and found that at normal levels of fluoride intake (0.5–1.0 mg. per day) the output in the urine and feces equals the intake. At high levels of fluorine intake retention occurs, although there is an increase in the amounts excreted. They found that the absorption of fluorine is related to the aqueous solubility of the fluoride salt and its state at the time of absorption. Retention occurs principally in the bones, which may undergo pathological changes under suitable conditions (59, 60). Such changes have been observed in persons living in regions where fluorosis is endemic. Shortt and co-workers (61) describe symptoms of rigidity of the spine and joint pain associated with fluorosis, while Mascheroni and Reussi (62) report finding evidence of osteosis at necropsy in the case of an individual who had lived in an area in Argentina where fluorosis is endemic. The first case of fluoride osteosclerosis due to drinking water in this country has recently been reported. The case was a young white soldier, 22 yr. old, who, for the first 18 yr., lived in a part of Texas where the drinking water contained from 4.4 to 12 ppm. fluoride (63).

Excessive ingestion of fluorine is capable of producing both acute and chronic poisoning. Relatively large doses of soluble fluoride may cause acute fatal poisoning within a few hours. Doses of 1.5–15 mg. per 100 g. of body weight fed daily to rats caused stunting of growth and death in a few weeks (29, 64). Two milligrams fed daily to rats for 3 mo. or longer caused striking changes in the teeth, particularly the incisors (65). Long periods of ingestion of 1–20 mg. of fluorine per kilogram of body weight per day by experimental animals has resulted in gross changes in the bones of these animals (60).

The limit set for the fluorine content of drinking water is 1 ppm. (4). Fairhall (2) states that in drinking water 180 ppm. has a toxic effect, 2–3 ppm. causes retention of the element, 1.2 ppm. causes mottled enamel, while 0.6 ppm. is without effect. Wells are usually the chief source of fluorine in regions where fluorosis is endemic, and the incidence of the disease may often be reduced by changing the supply to a surface water, as was done at Bauxite, Ark. The complete removal of fluorine from water, however, may not be desirable and there are recent data which indicate that small amounts of fluorine in water may be beneficial. It has been observed that in the United States the incidence of dental caries in children is considerably less in regions where fluorosis is endemic than in other regions (53, 66, 67). This observation has been verified by a number of workers in other parts of the globe, as cited by Ast (66). The hypothesis has therefore been advanced that it may be possible to protect against dental caries by the use of

fluorine. Cheyne (68) suggests the painting of teeth with 1 ml. of an aqueous solution of potassium fluoride (500 ppm.), while Ast (66) proposes the addition of fluorine to drinking water to bring its fluorine content up to 0.8 ppm., an amount too low to cause mottling of the enamel of teeth. Dean (69) also advocates the addition of fluorine for dental health, advising the addition of amounts up to 1 mg. per liter to fluorine-free waters. McClendon and Foster (70) working with rats showed, however, that the protection is only partial at 10 ppm. and that 50 ppm. appeared more effective. This would indicate that the effective level is several times higher than the level that will cause mottling of the enamel, but these findings cannot be applied to man since several investigators have shown that caries in the two species are not entirely comparable (22).

Selenium: Like fluorine, selenium in water is also a matter of regional importance. It occurs only in the soil, water and vegetation of certain areas and in the tissues of animals that use selenium-containing forage and water (71, 72, 73). The amount of selenium in vegetation seems to be independent of its concentration in the soil in which the plants grow. It depends more on the type of the plant, the largest amounts being taken up by those plants that normally absorb large amounts of sulfur (12, 72).

Selenium is extremely toxic to animals, its effects resembling somewhat those of arsenic (7). Curiously enough, it is reported that the ingestion of arsenic in suitable quantities will combat certain of the worst effects of the ingestion of selenium upon certain species of experimental animals. Rhian and Moxon (74) report that 13 ppm. of selenium in the diet of dogs did not produce symptoms of chronic poisoning when arsenic (as sodium arsenate) was added to the drinking water in a concentration of 5 ppm. Selenium is not considered a cumulative poison, but its effects, like those of arsenic, may be permanent. As little as 5 ppm. in food has been shown to have a harmful action on the liver (7). The eventual result of this liver damage in the case of experimental animals is the production of an advanced form of cirrhosis with all the signs of portal obstruction. Selenium intoxication in animals is known as "alkali disease" or "blind staggers," depending on whether it is chronic or acute. The minimum lethal oral dose is said to be 2–4 mg. per lb. of body weight, while toxic effects have been observed with diets containing 7.2 ppm. (74) and 8.5 ppm. (71).

Miller and Byers (75) believe that the presence of selenium in water, as compared with its occurrence in food, is of secondary importance and Knight states that its presence in water involves no great menace to public health (76). The correctness of these opinions has been confirmed by the observations of Smith and co-workers (77, 78) carried out in a section of Wyoming, South Dakota and Nebraska where selenium poisoning is endemic. They found that meat, eggs, milk and vegetables formed the most important and constant sources of selenium in the human diet and that of 44 samples of well water tested, 20 contained no selenium, 14 contained traces, while only 10 yielded concentrations ranging from 0.05 to 0.33 mg. selenium per liter. On the other hand, none of the 50 milk, 32 egg and 6 meat samples gave a negative result, the highest values being observed in meat with a range of 1.17 to 8 mg. per kg. These

investigators also found that selenium is widely distributed in body tissues following chronic poisoning, being present chiefly in the liver, kidney, spleen, pancreas, heart and lung (79). They observed that the bulk of the selenium stored in chronic poisoning is eliminated within two weeks after administration but that small amounts persist in the urine and liver for a month and possibly longer. Smith and co-workers (77) also studied the public health hazard of the ingestion of selenium and analyzed the urine of 127 subjects in 90 families. They found the concentration of selenium varying from 0 to 0.133 mg. per liter, only 8 per cent of the samples being free of selenium. Of the vague symptoms of ill health seen, none was sufficiently characteristic to be ascribed to the ingestion of selenium exclusively.

Byers (71, 72) has reported on the injury caused by the ingestion of small amounts of selenium, while Dudley (80) has shown how deadly the inhalation of as little as 0.02 mg. of hydrogen selenide per liter of air for 60 min. can be to animals. In view of these known facts and in spite of the secondary nature played by water in poisoning in seleniferous regions, the U.S. Public Health Service has set a limit of 0.05 ppm. of selenium (4), above which a water supply should be rejected. In the great majority of cases such a limit is easily met, but in seleniferous areas it is a problem, chiefly when rural domestic supplies depend on certain shallow wells (72).

Arsenic: The U.S. Public Health Service states that a water supply should be rejected if it contains more than 0.05 ppm. arsenic (4). This is a drastic change from the earlier limit of 0.15 ppm. (3) and is appreciably lower than the British limit of 0.2 ppm. In spite of the low limit set, there should be no difficulty in meeting the standard. Arsenic occurs only in traces if at all, in purified water (5) and traces of this element in water should not prove to be a public health hazard. That the ingestion of small amounts of arsenic is not a grave public health hazard has been shown by Neal and co-workers (81), who studied the possible hazard in exposure to lead arsenate spray, whether by ingestion from fruit (consumers) or by inhalation of spray mist (orchardists) or other forms of exposure. Over-dosage with arsenic causes gastro-enteric symptoms, liver destruction, multiple neuritis, chronic bronchitis and exfoliative dermatitis, but arsenic has long been used therapeutically, in a variety of ways and, in general, with but little danger.

Other Elements: Other elements, which in spite of their known toxicity have not been mentioned, are rarely present in any amount except the merest traces in purified or natural waters, and therefore do not constitute a public health hazard. Many of them may find their way into water supplies in traces when they are present as impurities in the metals and coatings of distributing systems. Toxic amounts of these elements could be obtained by individuals only under the most unusual circumstances, such as, for example, the malicious introduction of salts of these elements into drinking water.

Silver and barium may be mentioned, although they present no problem in this country insofar as drinking water is concerned. Rosenow (82) mentions the use of silver salts as a sterilizing agent but points out that the amounts which have been employed are small (0.015–0.04 mg. per liter),

much smaller than the quantities normally ingested with prepared food (0.06–0.08 mg. per day) (14). Although barium salts are highly toxic, this element would be precipitated by the sulfate of most waters. It is said to occur naturally in some waters in Switzerland and to remove iodine, thus producing an endemic goitrous condition of a much more severe type than occurs in this country (19).

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Cleveland's Mobile Emergency Pump

By S. C. Simmermacher

THE Cleveland Water Division has had many experiences with portable pumps which are used to remove water from excavations during construction and from craters resulting from water line breaks. Some of these experiences have been rather unfortunate and distressing. .

Until a few years ago the department relied upon a diaphragm type of pump. The single-diaphragm, hand-operated pump was carried by the repair crews for routine purposes. Double-diaphragm pumps operated by gasoline engines and mounted on trailers were employed for unusual demands. In the event of serious breaks in large mains, it was sometimes necessary to call into service all available equipment, both engine and hand-operated.

A number of years ago portable centrifugal pumps of various designs appeared on the market. Some of these had self-contained priming devices and some were designed for priming from the vacuum created on the intake side of gasoline engines. Although these pumps had greater capacities for comparable bulk and weight, they proved unreliable. On numerous occasions, in attempting to pump craters following bad water main breaks, the pumps failed to function. Perhaps the equipment was not always at fault. The men were accustomed to the use of diaphragm pumps in their routine work. The centrifugal pumps intended for major jobs were seldom used, so the men were not as familiar with their operation as they might have been. Failure to service the equipment properly after use sometimes left deposits in the priming line or caused the internal devices to become inoperative after standing idle for long periods. On several occasions failure of the protective devices on the vacuum primer permitted water to enter the gasoline engine cylinders and blow off the heads. Most of the trouble was on the pump end. After several such experiences the repair crews abandoned centrifugal pumps and depended upon the diaphragm equipment almost exclusively.

A few years ago the department was confronted with several construction jobs requiring portable pumping capacity entirely beyond the sphere of usefulness of diaphragm pumps. After exploring the field, a number of small gasoline-driven centrifugal pumps of the "contractor" type were obtained for testing. These were given rather severe service in regard to priming with high suction lift, pumping water high in mud, cinders, rags, string and other

A contribution by S. C. Simmermacher, Mech. Engr., Chief of Power Plants, Div. of Water & Heat, Cleveland, Ohio.

foreign substances. Some were found to clog in a matter of minutes under severe conditions; others continued to operate indefinitely without evidence of clogging or loss of capacity.

The internal designs were also examined very carefully for mechanisms that might become inoperative either because of foreign matter or after standing idle for extended periods. None of the pumps were without some shortcoming, but several gave quite satisfactory test results and from these was selected the one considered most satisfactory.

Trailer units, although fairly satisfactory, have several drawbacks. They are difficult to maneuver by hand on the job where ground conditions are bad. They also have no facilities for carrying hose, tools and equipment, and are easily neglected when out of service. On several occasions this equipment has been found with discharged batteries, dirty spark plugs, wet ignition or some other minor fault. To get the utmost in reliability and serviceability from such a pump, the unit shown on the accompanying drawing (Fig. 1) and in the photographs (Figs. 2, 3) was designed. It consists of a 6-in. centrifugal pump of the self-priming, non-clog type, mounted on a 1½-ton truck and driven from a split-shaft type of power take-off. The main pump specifications are listed in Table 1 and the chassis data are given in Table 2.

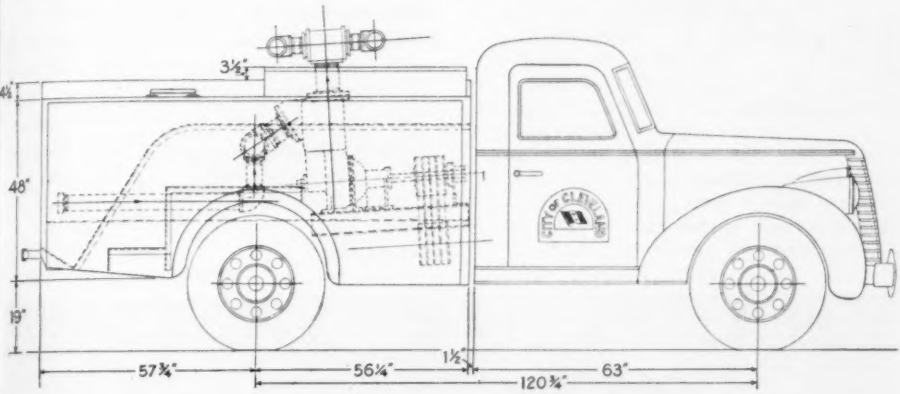

FIG. 1. Sketch of Emergency Truck Mounted Pump.

Numerous units have since been purchased in sizes up to 8 in. Various applications have been made—from a small pump that can easily be carried by one man, to the large sizes on rubber-tired trailer mountings. The small pumps are used by meter readers for pumping out manholes. Several of the small sizes are used by repair crews for pumping out pits and trenches and carrying away water from moderate leaks. The larger units are intended primarily for emergency breaks or when large volumes of water must be handled.

In previous experiences with various sizes and types of pumps it was found that hose larger than 4 in. was difficult to handle and resulted in much loss of time when haste was essential. This was particularly true on the suction side when high lifts required perfectly

tight connections. The pump of this unit is therefore equipped with fittings permitting the use of one or two 4-in. hoses on either or both suction and discharge. All the connections are used when maximum capacity is needed. One 4-in. suction and one 4-in. discharge often suffices. Although the original plan had the suction on the left side, the rear connection was found to be more convenient and both suction connections are carried to the rear of the truck. One discharge connection is carried to each side of the top of the truck; both discharge connections, however, are made with a long thread on a swivel, permitting them to be turned to either side if desired.

TABLE 1

Pump Data

Make	Gorman-Rupp
Model	B-16
Size	6 in.
Rated capacity	1,275 gpm. @ 1,750 rpm. & 50-ft. head
Horsepower required	30
Prime at suction lift (Pump actually primes at 28-ft. lift)	25 ft.

TABLE 2

Chassis Data

Make	G.M.C.
Capacity (total weight of chassis, body and equipment)	14,000 lb.
Actual weight ready for road, but without personnel	8,160 lb.
Wheel base	134 in.
Size of tires	7.00 × 20—8 ply
Rear wheels	Dual
Body (Special)	72 in. wide, 114 in. long
No. of cylinders	6
Piston displacement	228 cu.in.
Horsepower rating	85.5 @ 3,000 rpm.
Make of power take-off	Hercules
Type of power take-off	Split-shaft
Drive	V-belt
No. of belts	6

FIG. 2. Mobile Emergency Pump and Method of Connecting Suction and Discharge Hose

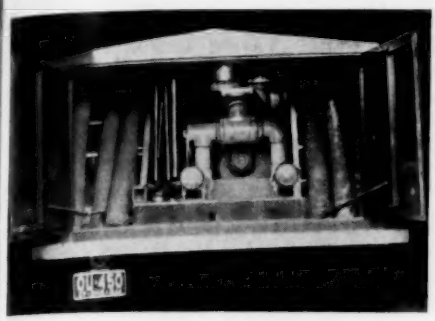

FIG. 3. Rear View of Truck Showing Pump, Suction Connections and Racks.

A steel body was designed to cover the pump and provide facilities for carrying the equipment. Access doors are provided on either side for inspection. A sliding cover on the top permits lifting out the whole pump if necessary. In back of the pump, curved racks are provided for holding the stiff sections of suction hose. The discharge hose is rolled up and carried on the floor of the truck.

Although the weight of the pump body and equipment is not great, the chassis is equipped with dual wheels to permit traveling over the rough and soft ground which is often encountered in the vicinity of water main breaks. To increase further the serviceability of the pump truck, a light portable generator and waterproof extension cords are carried to provide adequate lighting at night. A list of the equipment normally carried is given in Table 3.

Although the unit was designed and contracted for before Pearl Harbor, it was not completed at the time trucks were frozen. The original design called for bronze connections and fittings, but as these were not obtainable, galvanized iron was substituted. The original purchase of hose was also held up by priorities. After much delay, release of the truck, hose and other essential items was finally obtained during the summer of 1943, and the unit was given its first work-out in October of the same year.

TABLE 3

Tools and Special Equipment Normally Carried

4—10-ft. lengths 4-in. suction hose
4—25-ft. lengths 4-in. fire hose
2—4-in. bronze foot valves
2—4-in. bronze suction strainers
4—Spanner wrenches
2—Large valve keys
2—6-in. valve keys
1—2-in. valve key
4—Round nose shovels
4—Square nose shovels
4—Picks
2—Crowbars
2—Sledge hammers
2—5-gal. cans gasoline
1—2-gal. can lubricating oil
1—Trailer hitch
1—kw. portable lighting generator
Miscellaneous small tools

Up to the present time the unit has proved highly satisfactory. Whenever it has been taken out on a job, it arrived ready to run with all the equipment conveniently in place. If the pump stands idle for any length of time it is a simple matter to drive it out of the garage for routine testing and inspection and be assured that the whole unit is ready for use.

Water Works Design Under Wartime Conditions

By Wylie W. Gillespie

DURING the past three years the conditions created by the war emergency have made it necessary to modify and, in some cases, to ignore many of the water works practices which have become generally accepted from years of usage. Unquestionably, this will result in departures from previous standard practices which may prove permanently beneficial, but many of these deviations must be considered only as temporary measures and should not be permitted to enter into normal design after the present emergency.

Everyone who has had experience in the water works field will immediately call to mind many factors which have entered into water works design under wartime conditions. Included in these are such items as the unavailability of certain materials and equipment, the consequent necessity for providing only minimum facilities, shortage of available competent manpower and the constantly changing demands of war activities which have created conditions requiring immediate action—conditions which were not contemplated and which were beyond possible speculation only a few weeks before.

The subject of this paper is not adaptable to discussion by general treatment. Since our firm has had the privilege of participating in the solution of these problems on a number of different projects, it is my purpose to discuss particular problems encountered on actual installations and the methods of solution decided upon. We have had the opportunity to assist in providing water works facilities for several Army and Navy installations, but since the solution of these problems is largely controlled by military directives and requirements, we feel that a discussion of some of the problems recently encountered in providing municipal water works improvements in Florida may be of more particular interest.

One of the Florida communities which has suffered severe demands on its public utilities because of war activities is Panama City.

Panama City, located on the Gulf Coast approximately halfway between Tallahassee and Pensacola, is provided with one of the best natural harbors on the Gulf east of New Orleans. However, prior to the war, the principal industry in this city was a large paper mill. Except for minor commercial enterprises, Panama City was known principally as a summer resort. The 1940 census showed a population in Panama City of 11,610. Of this, 1,939 were located in the western area known as St. Andrews.

A paper presented on November 18, 1943, at the Florida Section Meeting, Ft. Lauderdale, Fla., by Wylie W. Gillespie, Cons. Engr., Smith and Gillespie, Jacksonville, Fla.

Early in 1941, the government began the construction of Tyndall Field, a permanent post of the Army Air Forces for flexible gunnery training. Shortly after this project was initiated, other installations for the Navy and Coast Guard were located at or adjacent to Panama City, and in 1942 construction was begun on the Wainwright Shipyard, to produce Victory and Liberty ships for the U.S. Maritime Commission. Other installations connected with the war effort were located adjacent to Panama City so that by July 1942 the population had increased to approximately 25,000. St. Andrews (the site of the shipyard) had increased to more than 15,000. In addition to the water demand for domestic purposes in this area, the shipyard then under construction anticipated requiring between 500,000 and 1,000,000 gpd.

Panama City extends approximately seven miles along St. Andrews Bay. The city water plant, which receives its supply from three gravel wall type shallow wells, producing less than 900,000 gpd., is located in the eastern portion of the city. The water demand in St. Andrews created by the shipyard and related housing projects was determined to be 1½ mgd., or more than 175 per cent greater than the entire available city supply. Since the city government had no means of financing the construction of water works facilities to meet this demand, a request was filed with the Federal Works Agency for financial assistance in meeting this problem. In connection with the FWA, a study was made which contemplated enlarging the supply to the city plant, increasing the capacity of the city filter plant and constructing sufficient large-sized transmission mains to serve the shipyard demands from the existing plant. Consideration was also given to constructing a new supply using shallow gravel-packed wells similar to the city supply and providing adequate treatment facilities to remove the excessive color found in this supply. After careful analysis, it was decided to secure a new supply located in St. Andrews from open bore wells extending into a lime rock aquifer. The water secured from these wells, while considerably harder than the city supply, was found to be entirely potable and compares favorably with the municipal supplies of many Florida communities using untreated water from deep wells.

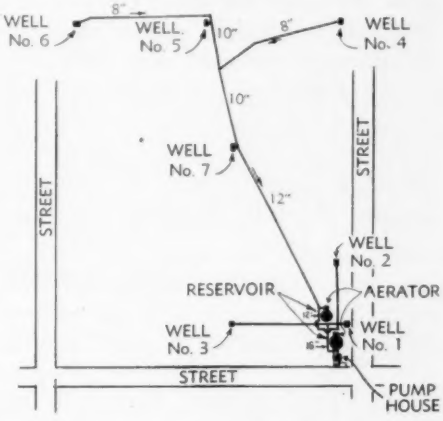

FIG. 1. Location Plan of Wells and Multiple Reservoir, Aerator and Pump House

Three wells (Fig. 1) were designed to produce ½ mgd. each. They were spaced approximately 1,000 ft. apart in order to avoid conflict in the cones of influence while pumping. The wells are 10 in. in diameter cased to approximately 400 ft. The casing is sealed with cement grout and the open bore hole extends to a depth of approximately 640 ft.

A system of well headers was designed to convey this supply to a new water works plant. The presence of

H_2S in this supply made a fairly high chlorine demand in the raw water. To reduce this demand and to provide a more potable water, aeration was provided by means of wood slot trays, designed on a basis of approximately 10 gal. per sq. ft. minimum. In order to provide a sufficient retention period following aeration to permit the H_2S to escape from the water and also to provide for adequate storage to meet peak demands, the project provided a 500,000-gal. concrete surface reservoir. Reinforcing steel was very difficult to secure at this time. Consideration was given to various types of reservoir construction which would provide the required capacity with a minimum amount of critical materials. Because of high ground-water table and poor foundation conditions, it was determined that the reservoir would have to be constructed almost entirely above normal ground surface. Consideration was given to multiple masonry arch construction (Fig. 2) with concrete buttresses similar to that which has been used successfully in several Army installations. It was decided to construct a circular reservoir, 91 ft. in diameter with 10-ft. water depth, of plain concrete. The concrete was designed for 3,500 psi. in compression and it was found that the actual tension in these walls when the reservoir was full, without any earth pressure on the outside, would be safely within the allowable tensile stress permitted un-

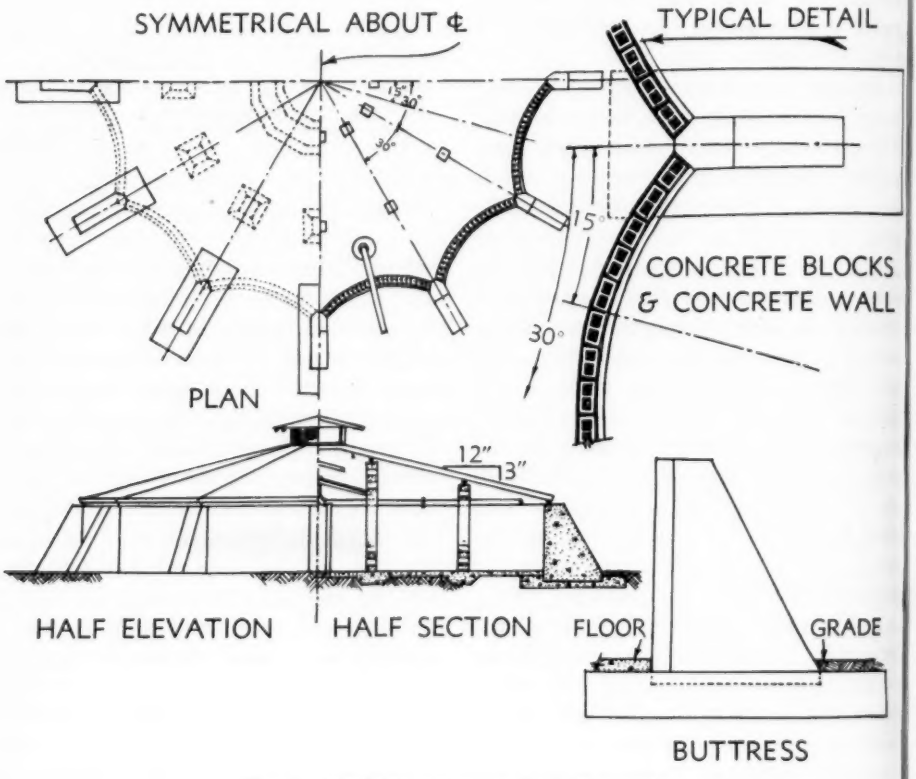

FIG. 2. Multiple Masonry Arch Reservoir

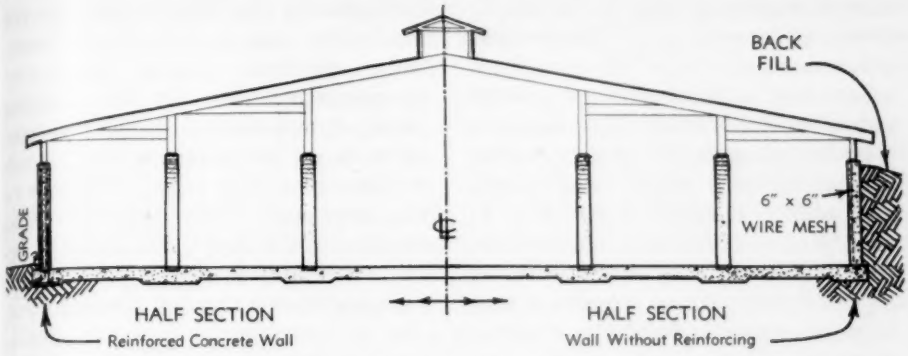

FIG. 3. Two Sections of Reservoir Showing Walls With and Without Reinforcing

der design standards established by the U.S. Navy. If the wall were kept at a uniform temperature it is probable that the plain concrete wall with no backfill on the outside would have been satisfactory, but since some cracks are inevitable, a backfill of selected material was placed around the reservoir using a 3:1 slope (Fig. 3—right half section). The tensile stress on the wall is, therefore, reduced to less than 100 psi. The reservoir has been in use for more than a year and to date no cracks have developed in this unique structure.

Service pumps, designed for a maximum demand of 2,000 gpm., were provided in a wood frame building which also houses an automatic solution feed chlorinator (Fig. 4). Chlorine is supplied to the suction side of the pumps. Following the aeration and average 8-hr. retention, the water has practically no actual chlorine demand, therefore, chlorination is only to provide a residual which will insure protection for human consumption.

A system of cast-iron mains was designed to supply the shipyard and the several housing projects constructed by the federal government in this area. This system is connected to the city system previously in place, but these two systems are physically separated by a closed valve, thereby preventing the harder water from the St. Andrews supply from mixing with the softer water supplying the balance of the city.

This installation as described was first placed into operation about November 15, 1942, although some phases of construction continued until the close of the year.

Contracts for the production of additional ships required further expansion of the shipyard facilities and the employment of a larger number of workers. Housing facilities were provided for these workers so that by June 1943, it became evident that the population of St. Andrews would exceed 28,000 by the end of this year and the population of the entire city would be approximately 60,000. The increased production facilities of the shipyard required a water demand of 1,200,000 gpd., with peak flows of several times this average rate. Almost as soon as the 1½-mgd. facilities were completed, the increased demand demonstrated that this supply was entirely inadequate and that an additional 2-mgd. supply would be required as soon as it could be constructed. Funds were provided for this work and it be-

came necessary to adapt these new facilities to incorporate the construction just completed with as little loss in materials and workmanship as possible, and to provide for keeping the existing plant in operation during the construction of the new work. Accordingly, four additional supply wells (Fig. 1), wells Nos. 4, 5, 6 and 7, similar to the three previously built, were constructed, together with a new system of well headers, aerator, a 500,000-gal. surface reservoir and service pumps. Additional distribution piping was required to serve the new housing projects and the increased shipyard demand.

One of the problems in designing this new construction and conserving the work previously performed was encountered in the electrical service for the pump station and supply wells. Since the three original wells were comparatively close to the pumping plant, a transformer bank was provided at the pump station and secondary service was distributed to each of the three wells. The four new wells required much longer lines, and it became necessary to receive power at the pumping station through a primary meter, to continue the primary lines to each of the well sites and to provide individual transformers for the service to each well pump. A considerable saving in critical materials was thereby effected.

At the time of the design of these additional facilities, it was found that

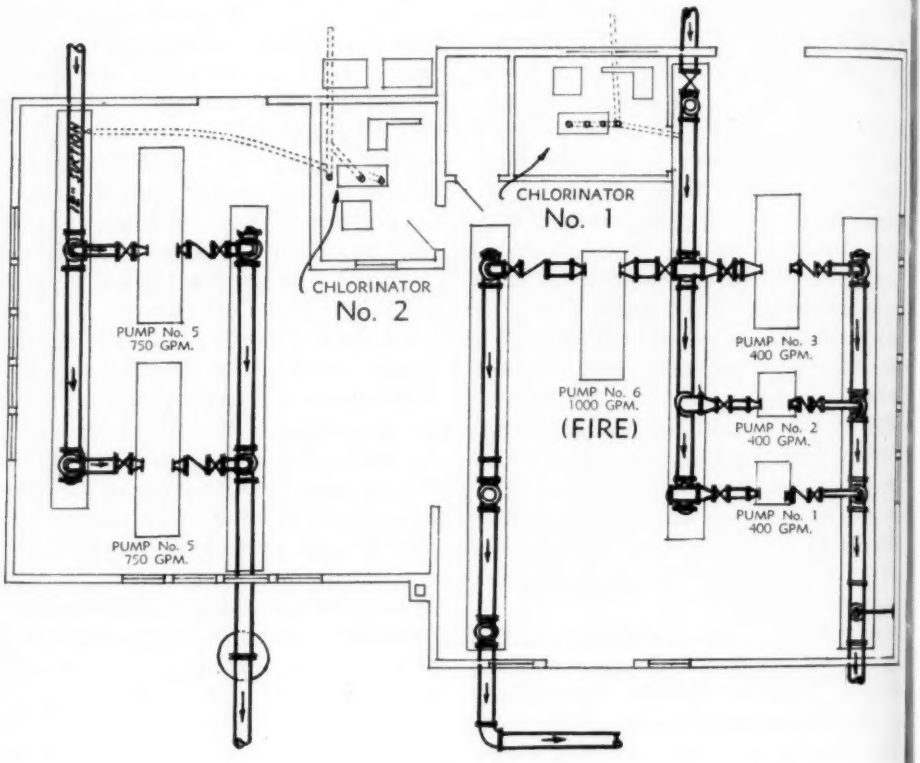

FIG. 4. Pump House Piping

reinforcing steel had become more readily available and that there was no convenient material, suitable for the backfill required, for a reservoir designed similar to the one previously built. Consequently, the second reservoir was designed of conventional reinforced construction, using values of F_c 800 psi. and F_s 20,000 psi. In the design of the wall reinforcement (Fig. 3—left half section) no attempt was made to utilize the effect of the rigid joint at the base as the tank is com-

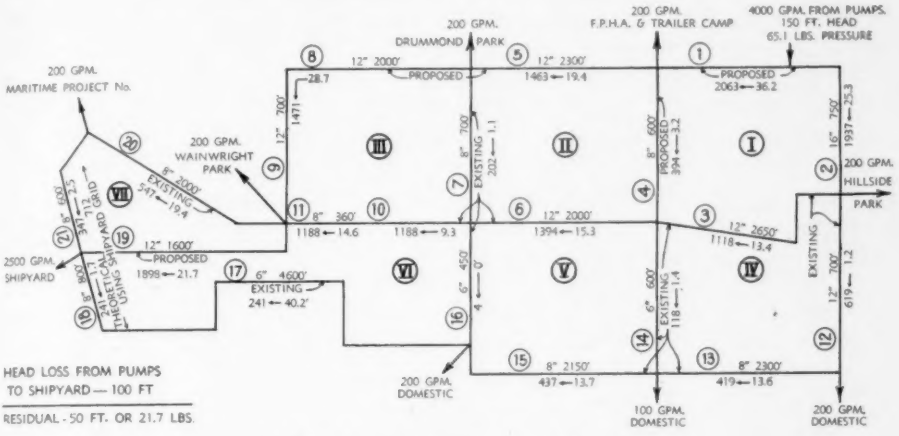
200 GPM. MARITIME PROJECT No.
200 GPM. DRUMMOND PARK
200 GPM. F.P.H.A. & TRAILER CAMP
4000 GPM. FROM PUMPS. 150 FT. HEAD 65.1 LBS. PRESSURE
200 GPM. WAINWRIGHT PARK
200 GPM. HILLSIDE PARK
2500 GPM. SHIPYARD
200 GPM. DOMESTIC
100 GPM. DOMESTIC
200 GPM. DOMESTIC
HEAD LOSS FROM PUMPS TO SHIPYARD — 100 FT
RESIDUAL - 50 FT. OR 21.7 LBS.

FIG. 5. Water Flow Analysis

paratively shallow and the saving in steel would have been negligible. The allowable stress in the ring tension bars was limited to 14,000 psi, and small bars were used to afford the maximum bond per pound of steel. In this way the main problems of temperature and expansion were minimized as much as possible.

In order to determine the required pipe sizes for the distribution system constructed, an analysis (Fig. 5) was made by the Hardy-Cross method using a value of $C = 100$ and providing for the flows required with a residual of 50 ft., or 21.7 lb. Approximately 20,250 ft. of cast-iron main were installed in the original construction and approximately 14,000 ft. were installed in the supplemental work. A total of approximately 6,500 ft. of well header was required. These well headers are designed to handle the flow from all wells when operating simultaneously, without friction, increasing the total head beyond that contemplated in the pump design. In planning these well headers, consideration was also given to insuring that the small friction developed when only one well was operating would not reduce the total head sufficiently to overload the pump motor.

Meters were provided to measure the flow from each well. The entire pumpage of the St. Andrews station is metered by an indicating, integrating, and recording electric flowmeter actuated by a 16-in. Venturi tube. The completed pump station has three 400-gpm. service pumps (one is dual driven) and one 1,000-gpm. engine-driven fire pump operating from one suction line. There are two 750-gpm. electric-driven service pumps operating from a second suction line. These suction lines are inter-

connected so that either system of pumps may operate from either or both of the two surface reservoirs. The discharge piping is connected in a common header so that the flow is metered by the Venturi tube. Two chlorinators are provided, applying chlorine to each of the two suction lines.

This work was performed as a project of the FWA and is operated by the city of Panama City under a lease arrangement with that agency. The wells were constructed by the Layne-Central Co. of Memphis, Tenn., who also furnished and installed the deep-well turbines. The service pumps were furnished by the American Well Works, and the chlorinators by Wallace & Tiernan Co., Inc.

This St. Andrews plant, with a capacity of 3½ mgd., is more than three and one-half times larger than the existing city plant. Although this plant is supplying approximately 200,000 gpd. formerly served by the city plant but now included in the St. Andrews system, the increases in population in the other sections of Panama City have created a demand in excess of the present facilities of the city plant, and plans are now being made to provide an additional supply and additional distribution reinforcement to solve this need.

While most of the problems herein discussed are not unusual in themselves, it is believed that some of the procedures followed in constructing this work under wartime conditions may involve features sufficiently different from customary practices to prove interesting.

Quality and Quantity of Plankton in the South End of Lake Michigan in 1942

By James B. Lackey

IN a recent paper, Howson (1) comments on the reasons for the slow adoption of filtration by the cities using water from the Great Lakes. These include low turbidity, relative freedom from sewage pollution and little trouble from taste and odor. The same paper also points out that there has been a gradual increase in pollution, in objectionable taste and odor troubles and in the cost of treatment.

With the rise in population and the great industrial development of some areas bordering the Great Lakes, it was inevitable that the raw water quality would be impaired at least close to the shores of such areas, as for example the southern end of Lake Michigan. This paper will not deal with the bacterial quality of the water, as there are excellent recent papers on that subject by Streeter (2) and Crohurst and Veldee (3) and an abundance of data in the files of the cities using the lake water.

Plankton surveys of Lake Michigan are few in number; some have a direct bearing on water supply problems, some are in the field of pure research. The above papers show a restricted plankton population for the lake and all show about the same plankton types, predominantly diatoms and yellow-green flagellates. Both types are known to cause trouble in water purification, therefore their number, distribution and periodicity are of interest. Most members of both groups are adversely affected by pollution from domestic sewage. The Howson paper refers to a gradual increase in pollution, as well as to increased taste and odor troubles, therefore, it becomes worth while to see if there is an increase in these forms or in other plankton organisms.

Such an increase is difficult to determine, as no single agency has taken samples from the lake for a long period of time. Ahlstrom (4) made an extensive survey covering many points in the lake. He found 70 genera and 172 species of algae and protozoa, and characterized the lake as a *Dinobryon* lake. Eddy (5) gave a general picture of the plankton for Lake Michigan and quantitative results for part of his material. Baylis and Gerstein (6) gave quantitative results for the Chicago area, while papers by Damann (7) and Daily (8) included some quantitative work.

The figures of Eddy might be used as indicative of plankton numbers present in 1927, but those of Baylis and Gerstein in 1927, 1928 and 1929 showed a more abundant plankton in the same general lake area. Damann recorded 1,052 organisms per ml., while on April

A contribution by James B. Lackey, Sr. Biologist, Stream Pollution Investigations, U.S. Public Health Service, Cincinnati, O.

28, 1929, Baylis and Gerstein found 6,050 per ml. Constituent organisms were not named, but it may be assumed that a large number of these were diatoms. Eddy found 60 genera, Baylis and Gerstein found 46 in the lake. All of these workers are in fairly general agreement: there is a rather sparse plankton population dominated by diatoms and Chrysophyceae.

The small number of species is typical of such lakes as Lake Michigan. This is a deep lake whose dissolved solids are low. Its watershed is in a region of granitic rocks whose solubility is slight and such areas tend to produce acid or slightly alkaline waters. Partly because of this and partly because of its great depth—antagonistic to a productive bottom for plankton—Lake Michigan belongs to a group of lakes tending to be low in productivity, which are termed oligotrophic.

Such lakes change with age. Even as large a lake as Zurich is made more productive (eutrophic) by the admission of sewage. It is estimated that since 1885 Zurich has attained the characteristics of a eutrophic lake. It is evident that Lake Michigan has not been made more productive by the sewage of the cities on its banks, but it might be possible for some enrichment to have occurred at the more shallow south end, adjacent to Chicago. Therefore, studies were made to determine the quality and quantity of plankton present in this area.

Beginning on March 15, 1942, periodic sampling of raw lake water was begun. Samples were taken first in the well at Dunne Crib intake. Later an outside sample was also taken, and in July and August six sets of samples were taken on lake surveys. The locations of all these sampling points are shown in Fig. 1. In all, 117 Dunne Crib samples and 48 lake survey samples were examined. Two sets of Calumet River samples, ten in all, were examined.

These samples were normally 400 ml. of raw water dipped from the lake and preserved by the addition of 20 to 30 ml. of formalin, then set aside in the dark for seven days or more, after which the supernatant water was decanted and the residual of 15–20 ml., containing the plankton was sent to the laboratory for examination. During the week of July 19, a visit was made to the laboratory at the Experimental Filtration Plant in Chicago, and both centrifuged and fresh samples were examined as a check on the identification of forms in the preserved samples. An excellent agreement was found.

Species Encountered

Table 1 shows the groups of plankton algae and protozoa encountered and the percentage of samples in which they occurred. The small list of species (172) is striking. A similar number (117) of samples from almost any stream in the Ohio River Basin would yield from two to three times as many species (9), and most of the stream samples examined at the Cincinnati Laboratory have been 100-ml. instead of 400-ml. samples. Stream samples usually are well-mixed by current, whereas in a lake there is a tendency for plankton to be stratified, some species occurring at one level, others at another. The greatest aggregations are usually at the surface. In the Dunne Crib samples, those from outside the well usually contained greater numbers than those inside. Because of the location of the openings in the well wall, and currents due to pumping, the

TABLE 1

Groups of Plankton Organisms Found in Lake Michigan, South End, 1941–42

Group	Number genera	Number species	Total occurrences all samples	Highest % occurrence noted	Species having this occurrence	Significance of group
Fungi	5	5	26	7.7	*Blastocaulis sphaerica*	No special significance.
Bacillariaceae	17	27	1844	99.0	*Tabellaria fenestrata*	Most of these common to water of good sanitary quality. Sudden blooms of some clog filters. Others cause tastes and odors.
Myxophyceae	12	14	184	42.6	*Oscillatoria* spp.	Some species cause bad odors. Abundance here may indicate some pollution.
Chrysophyceae	7	10	303	66.0	*Dinobryon* spp.	Usually found in water of good sanitary quality. Often cause bad odors.
Cryptophyceae	2	3	121	69.7	*Cryptomonas erosa*	Usually found in water of good sanitary quality. Often cause bad odors.
Dinophyceae	5	6	144	37.0	*Peridinium quadridens*	No special significance
Euglenophyceae	2	7	23	2.6	*Euglena polymorpha*	No special significance.
Volvocales	9	9	32	7.0	*Chlamydomonas* sp.	No special significance. Dense blooms of some species indicate pollution.
Chlorophyceae sensu strictu	35	49	626	38.7	*Oocystis* spp.	Variety indicates clean water of low organic content. Some gelatinous ones as *Elakatothrix* may carry bacteria through chlorination into chlorine deficient areas.
Mastigophora	11	11	180	34.2	*Bicoeca lacustris*	No special significance here.
Sarcodina	7	7	27	5.2	*Raphidiophrys pallida*	No special significance here.
Infusoria	22	23	257	16.8	*Cyclidium glaucoma*	No special significance here.

well samples probably represent a mixture of surface and deeper water.

A comparison of well samples and those taken from outside at the surface shows that the two types are rather closely alike in composition. It therefore seems that the samples used for this study represent largely surface water—at least they are not deep water samples—so that organisms tending to be restricted to the depths of the lake are not included in the study.

It should be stated that species determination was not attempted for several genera of diatoms, for the genus *Dinobryon* and for *Scenedesmus.* It was also impracticable for certain ciliates which occurred in about 30 per cent of the samples. Almost all of these samples were preserved with formalin, and many ciliates are difficult to identify after formalin preservation. If all genera and species had been correctly identified, the list would have been much longer. As it is, the number of genera in these samples was about twice the number reported by Ahlstrom and Eddy, and four or five times the number reported by the other three writers mentioned above. Only Ahlstrom showed an equivalent number of species, and his diatom list is largely responsible, as he reported 63 species not found in the present samples. Judging from Table II, there has been an increase in the variety of plankton organisms present in the south end of the lake.

Many of the species are present for long periods of time or recur frequently. *Tabellaria fenestrata* occurred in 99 per cent of the samples. Five diatoms occurred in 90 per cent or more, two in 75 per cent or more, four in 50 per cent or more, and four in 25 per cent or more. In addition to these diatoms, *Dinobryon* spp. and *Cryptomonas erosa* occurred in 50 per cent or more samples, while *Oscillatoria* spp., *Chrysosphaeraella longispina, Mallomonas* spp., *Peridinium quadridens,* unidentified dinoflagellates, *Ankistrodesmus falcatus. var. mirabilis, Elakatothrix gelatinosa, Oocystis* spp.,

TABLE 2

Numbers of Genera and Species of Protista Found in Lake Michigan

	Eddy 1927		Damann 1938		Daily 1938		Baylis and Gerstein 1929		Ahlstrom 1936	
	Genera	Sp.	Genera	Sp.	Genera	Sp.	Genera	Sp.	Genera	Sp.
Bacillariaceae	21	26	13	13	19	26	16	17	27	90
Myxophyceae	8	9	7	7	8	9	4	4	9	15
Chrysophyceae	3	3	2	2	3	3	3	3	4	10
Heterokontae	1	1							1	1
Cryptophyceae	1	1								
Dinophyceae	2	2	2	2	2	2	2	2	2	7
Euglenophyceae	3	3								
Volvocales	3	3					1	1	2	2
Chlorophyceae sensu strictu	15	20	6	6	11	11	12	12	20	40
Mastigophora									1	1
Sarcodina	4	4					3	3	3	4
Infusoria	5	5					4	4	2	2
Totals	66	77	30	30	43	49	45	46	71	172

Scenedesmus spp., *Bicocca lacustris* and *Monosiga ovata* all occurred in 25 per cent or more samples. This list is interesting because it includes certain organisms which have given trouble in water supplies at other places. *Synedra* for example, has been cited by Conger (10) as a cause of filter stoppage at Washington, D.C. Many of the diatoms supposedly cause taste and odor, and the same is true of *Dinobryon, Cryptomonas, Chrysosphaerella, Mallomonas* and possibly certain dinoflagellates. In addition to these, *Uroglenopsis* was noted in 5 per cent of the samples, and frequently small green cells which were almost certainly the dissociated cells of this organism were found. Colonies of this organism disintegrate very readily, hence may cause trouble when not suspected of being present. It appears then that certain organisms (known to have caused trouble) may be found in the lake either at irregular intervals or for long periods.

Increase of Organisms

Indications from this study are that such types and numbers of such organisms have increased in the area studied. Table II shows that more genera of blue-green algae; more genera of Chrysophyceae, Dinophyceae, and Volvocales were found, besides increases in the genera and species of groups not usually rated as causing trouble. This is particularly true with respect to *Chrysosphaerella, Uroglenopsis* and *Mallomonas,* forms which have been reported, but apparently not in considerable quantities. One interesting feature has been the failure to find *Synura,* reported by several observers. The apparent increase in types of organisms may be highly important, pointing to an enrichment of the water in the south end of the lake. If this is the case, tastes and odors in the water will be more marked, and drinking water turbidity will be raised. All of this adds further evidence of the need for filtering the lake water by those communities using it.

Marked Variation

Total numbers of organisms show marked variation. The highest number was 2,576 per ml. on April 6, and the lowest was 54 per ml. on August 27. This maximum is less than half the maximum reported by Baylis and Gerstein, but whether the difference is apparent or real is not known. The amount of surface plankton enumerated is dependent on such factors as wind direction, blooms or local swarms, methods of collection, etc. In the present work only living organisms, i.e., those whose cell structure was typical of living cells, were counted. The average number for 165 samples, most of them from Dunne Crib, but a few from other points (Fig. 1) was 715 per ml. of raw water.

This number is not large when compared to river water, where as many as 33,000 per ml. have been found (9), but it is far in excess of the number normally present in filtered water. Furthermore, there is a greater chance for the enhancement of odors in this unfiltered water. Where organisms are caught by a filter, the odorous qualities of the water can be detected and the water treated after leaving the filter. But these living organisms carried into the distribution system die there, if not at once killed by the pumps as they pass in. And on death, the oils are freed, so that the troubles are present where it is difficult to treat them. It should be borne in mind too, that *Chrysosphaerella* and *Uroglenopsis* are colonial organisms, the later often be-

ing a colony 0.5 mm. in diameter and containing over a thousand cells, so that a single colony per liter would be the equivalent by volume of 0.0645 ppm. Actually as many as 250 colonies of *Uroglenopsis* per liter, or 17.125 ppm., were recorded. Along with these were other Chrysophyceae and Cryptophyceae, so there is little wonder that odors are reported at times.

In the absence of previously published detailed enumeration, it is difficult to state categorically that plankton is increasing in this area of the lake. The types apparently are, however, and this is a logical expectation. Also, the types are those which may be expected to increase odor troubles.

The diatom flora may be increasing in numbers and in species, but there has always been a substantial diatom flora in the lake and these plants seem to thrive better on a very low nutritional plane than some others. Cryptophyceae and Chrysophyceae seem to favor cold waters and perhaps a slightly richer nutritional environment than diatoms. They seem to be increasing in types, probably in numbers, at the south end of the lake. Since many of them cause trouble, any increase in their population would increase water problems. Chlorophyceae apparently favor warmer waters than this lake; in Erie, e.g., they are more abundant. They are not greatly troublesome, but if they remain low, the growth of other organisms is more prolific.

These are all photosynthetic forms and it might be possible to escape them, at least for a while, by lowering the water intakes. If the amount of organic matter admitted to the lake increases from year to year, however, this is but a temporary expedient. The south end is shallow; the ten-fathom contour line from Evanston to Gary is between five and ten miles out, so that to get beyond the influence of light and wind circulation of the upper waters would necessitate moving out a considerable distance. The trend is gradually to increase treatment of the lake water by filtration.

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Developments in Split Treatment Water Softening

By Donald Walker

THIS paper deals with the cold lime softening of water—a new technique in water plant design and operation that has proved successful in several installations. The technique is not a radical departure from, but rather an evolution or development of, an old "tried and true" practice.

This new development produces a completely stabilized water that will not show any alkalinity drop through the filters, does not need recarbonation and allows more tolerance in plant operation.

Many existing plants could be converted to this new method by the addition of another rapid mix tank, or by converting some existing settling capacity to rapid and slow mixing units.

In the past, the term "split treatment" has been applied to all types of plant operation. In general, it has come to be known as a makeshift or auxiliary method of plant operation rather than as a modern method. One authority states that split treatment consists of treating as large a portion of the supply as possible for maximum reduction in hardness and then adding the untreated portion to neutralize the excess hydrate alkalinity. He further states that this is not modern practice and is not as effective in reducing hardness as the "overtreatment" process.

According to the A.W.W.A. Manual * this slow incrustation can be avoided, if, after neutralization, the water is mixed with an excess of $CaCO_3$ sludge and then settled before filtration (1,500 ppm. was suggested). W. A. Sperry (*see* Jour. A.W.W.A., **6**: 215 (1919)) was one of the first to try this commercially and found that large amounts of return slurry had a tremendous effect in reducing the residual total alkalinity and magnesium content of the water.

Many plants tried this slurry recirculation unsuccessfully because the recirculated sludge contained organic matter undergoing putrefaction which imparted a taste and odor to the water being treated. Some plants found that the recirculation eventually caused a "milky" condition in the settled water, and abandoned slurry recirculation. In each case these plants were attempting to use alum as a coagulant.

A.S.C.E. Manual No. 19 (1940) suggests recarbonation of water just sufficient to precipitate the excess lime. This is to be followed by a second stage of coagulation and settling before filtration. The A.W.W.A. Manual fur-

A paper presented on November 19, 1943, at the Florida Section Meeting, Ft. Lauderdale, Fla., by Donald Walker, Chief Engr., The American Well Works, Aurora, Ill. A similar paper was presented at the Minnesota Section Meeting, St. Paul, Minn., March 16, 1944.

* Manual of Water Quality and Treatment (1940).

ther recommends recarbonation of the second stage effluent just sufficient to neutralize the non-carbonates.

Recent Development In Split Treatment

Many investigators have been attempting to work out a method of water softening that would be simple in practice and allow sufficient leeway in operation so as to turn out a stabilized water that would not require tempering with carbon dioxide. They desired to use all the stabilizing advantages of recirculated slurry and at the same time avoid magnesium and taste complexes. Some form of split treatment seemed to offer the operating characteristics desired. At Ann Arbor, Mich., development work on a full plant operation scale has produced a method of softening ordinary waters that is more trouble free and dependable than experienced heretofore. By this method it is entirely feasible to soften most waters to any reasonable degree and at the same time to obtain a settling tank effluent so completely balanced that no incrustation will take place on the filter sand, nor will the water be the least bit aggressive.

Approximately 75 per cent of the water is directed into the primary rapid mixing basin and the remainder (25 per cent) is diverted directly to the second-stage rapid mixing tank.

The major portion (75 per cent) flows through the primary (first) rapid mixing tank, the slow mixing basin and then through the settling tank where the precipitates are continuously removed for recirculation by flight conveyor mechanisms. Approximately 2 to 3 per cent (by volume) of slurry is maintained in the first mixing tank. This overtreated water then joins the untreated fraction in the secondary rapid mix tank.

All of the lime is added to the major flow and no alum is used in the process. The caustic alkalinity is raised to around 70 ppm. in excess, and the pH is carried around 10.8 to precipitate the magnesium hydroxide (which starts precipitating at pH 10.3). By keeping the hydrogen-ion concentration low, the magnesium is discharged nearly to the solubility limit, and the formation of soluble basic complex magnesium compounds is avoided.

The overtreated and untreated fraction, secondary return slurry and activated carbon, together with all of the soda ash, are thoroughly mixed in the second-stage rapid mix basin. Slurry from the secondary settling tank is advantageously used because it consists principally of calcium carbonate. This slurry does not increase the hardness of the water by the formation of magnesium compounds since nearly all of the magnesium present is in the form of magnesium sulfate; it will not impart tastes and odors since 75 per cent of the putrescible matter is deposited in the first stage, and the activated carbon is recirculated in the second stage.

Enough calcium carbonate slurry is recirculated to maintain at least 1½ per cent of settleable solids in the second mixing basin, consisting mostly of calcium carbonate and a small amount of carbon.

After thorough, rapid agitation, the mixture is slow mixed for floc formation and settled for about 80 min. (tank filling time). The settled effluent is so stable as not to require recarbonation and is passed on to rapid sand filters without further treatment.

This flow sheet has worked so perfectly at Ann Arbor that when a recent large water softening installation at an

industrial plant was built near Ann Arbor, the engineers decided to follow in general the Ann Arbor flow sheet for softening their water of 270 ppm. hardness and 21 ppm. magnesium.

The subsequent operation of this plant has borne out the Ann Arbor experience and a balanced water is being economically produced without the aid of recarbonation or use of any other acid.

Other plants have been constructed since, at least one using the waste slurry from the second stage as a product of commercial calcium carbonate.

Looking into the future, this method also makes strongly feasible the calcining of waste second-stage slurry. This will reduce operating costs and alleviate one of the greatest nuisances of softening—sludge disposal.

Plant Operation Control

In general, the daily routine control of plant operation is centered around samples taken at a station where the flocculated first-stage liquor is about to enter the first settling tank. At this point the lime reactions have gone to sufficient completion to avoid erratic results, and stabilization reactions should have taken place.

The sample is checked for the optimum causticity for the greatest magnesium reduction. In practice, lime is added just to the point where the rate of magnesium reduction flattens out (plotting $Ca(OH)_2$ added against magnesium content of the sample).

Actually, after gaining familiarity with a given water, it is possible to approximate this point by running the alkalinity relations on the sample, thus avoiding the more tedious magnesium curve work.

For further and more detailed information as to this technique and split treatment operation results, readers are referred to Harry McEntee, Supt. of Operation, Water Treatment Works, Ann Arbor, Mich.

In one plant, to avoid poor settling of colloidal precipitates in the second stage, presumably due to the accumulation of aluminum hydroxide from slurry recirculation, the use of alum was abandoned and a small amount of primary magnesium sludge was pumped to the secondary rapid mix tank to act as a coagulant. There was no taste problem involved in using a very small amount of the first-stage sludge as a coagulant.

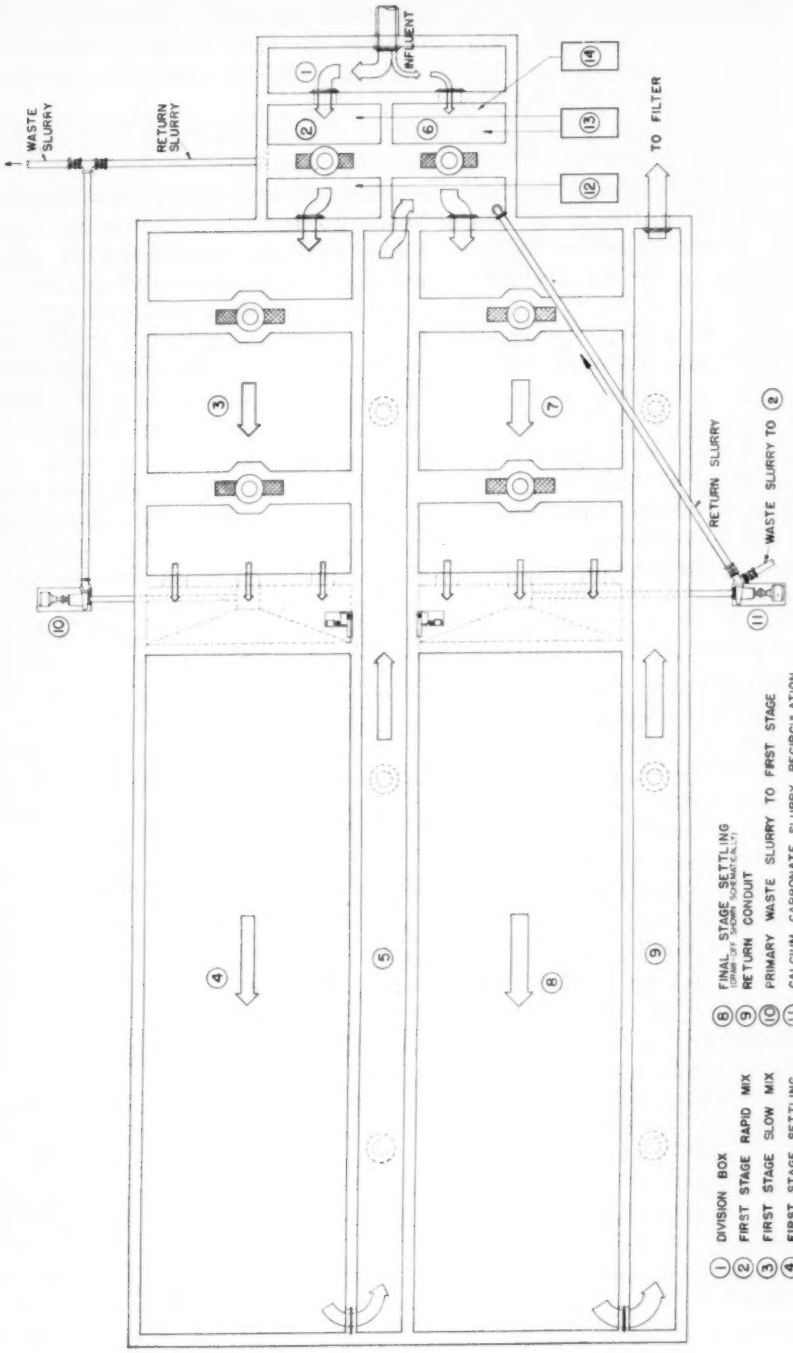
The Ann Arbor plant had also tried the use of some first-stage magnesium slurry in the second stage, to act as a coagulant. The result was a clearer basin effluent, but an increase in alkalinity and magnesium in the finished water. The clearer water did not give better filter runs, and the practice was abandoned.

In other respects, the operations of the two plants are similar. Both are equipped to feed CO_2 if necessary, but neither plant uses it.

Mechanism of Stabilization

When the overtreated and raw waters are mixed together in the second stage, the excess lime acts upon the untreated fraction which gives up much of its hardness, and tends to neutralize excess alkalinity.

The first-stage water, being greatly supersaturated with hydrates and carbonates, is extremely susceptible to giving up its excess load to any contact surfaces which are in rapid motion. This is quite apparent in operating the rapid-mix equipment. The impeller causing the violent agitation to mix thoroughly the water and slurry, rapidly takes on a coating of glass-like


INFLUENT
WASTE SLURRY
RETURN SLURRY
TO FILTER
RETURN SLURRY
WASTE SLURRY TO (2)
① DIVISION BOX
② FIRST STAGE RAPID MIX
③ FIRST STAGE SLOW MIX
④ FIRST STAGE SETTLING (DRAIN OFF SHOWN, SUCTION ALSO)
⑤ RETURN CONDUIT
⑥ FINAL STAGE RAPID MIX
⑦ FINAL STAGE SLOW MIX
⑧ FINAL STAGE SETTLING (DRAIN OFF SHOWN, SUCTION ALSO)
⑨ RETURN CONDUIT
⑩ PRIMARY WASTE SLURRY TO FIRST STAGE
⑪ CALCIUM CARBONATE SLURRY RECIRCULATION
⑫ LIME FEED
⑬ SODA ASH
⑭ COAGULANT

SPLIT-TREATMENT PROCESS

calcium carbonate which builds up coatings of ½ in. per month. The build-up is greatest where the motion is the greatest and almost nil where the motion or turbulence slows down.

The crystalline recirculated calcium carbonate particles present a large contact surface area. Agitation puts these multitudinous surfaces into motion so that an intimate contact is effected between the solution and the solid phases. These rapidly moving particles seem almost to "explode" the supersaturated solution and cause the water to give up nearly all of the unstable compounds which "grow" on the slurry particles.

The combination of greatly overtreating a large portion of the water, and then neutralizing this with the untreated flow, and at the same time rapidly mixing the whole in the presence of a large amount of calcium carbonate precipitate, results in a softened and completely balanced water.

The enormous amount of recirculated slurry that settles just after leaving the mixing zone also acts in the nature of a filter, since the settling tank effluent can be caused to flow upward through this downward settling slurry blanket. This gives mechanical straining or filtering of small particles which minimizes the need for long-period settling basins and gives an effluent of low turbidity. This mechanical filtering action is most possible when enormous amounts of slurry are maintained in the mixing tank through good mixing and sludge return, and when the influent to the settling tank is fed in as underflow.

It has been observed, however, with this Ann Arbor form of split treatment, that precipitates which are carried over to the filter from the second stage do not shorten the filter runs and, consequently, no particular attention has been paid to the turbidity of the final stage effluent. The crystalline calcium carbonate particles that are carried over to the filter do not act like gels and tend to help filtration rather than to hinder it.

Laboratory Jar Work

Investigational work was done by the Aurora Laboratory for a better understanding of the mechanism of this new form of split treatment.

The water tested was a typical 250 ppm. hardness water containing 22 ppm. of magnesium. The samples of water were split 75–25 and chemicals and slurry added consistent with the process. Before analyzing, the samples were filtered to eliminate false reactions.

Calcium carbonate slurry precipitated from a short-period blanket type plant of single-stage operation was collected and used as contact material in one series of the tests. Also, CP calcium carbonate was used in a duplicate series of tests.

The treated water samples were split three ways and tested under the following conditions of contact between the water and precipitated slurry:

(1) The treated water was caused to flow upward through a tall, vertical cylinder packed with a slurry blanket so that intimate contact was maintained between the flowing water and the slurry blanket. This amounted to blanket filtration. The water was passed through the various depths of slurry blanket and analyzed.

(2) A jar was loaded with treated water and slurry to the extent of 1½ per cent of dry solids. A slow-speed agitation device (flocculation) was used to slow mix the contents. Water was taken off from time to time, settled and analyzed.

Split Treatment Process
SODA ASH
COAGULANT
FINAL STAGE RAPID MIX
FINAL STAGE SLOW MIX

TABLE 1

Summary Using Calcium Carbonate Slurry Containing Magnesium Hydrate

	Total Hardness	MO Alkalinity	P Alkalinity	pH	Mg
Raw water	340	255		7.3	31.1
Treated water—12.6 gpg. CaO	186	146	132	10.5	13.6
Blanket contact—3 ft.	170	116	96	10.5	13.5
Blanket contact—9 ft.	165	113	95	10.5	13.5
Slow mix—20 min.	104	30	21	10.0	9.7
Slow mix—60 min.	92	24	10	9.6	8.7
Rapid mix—20 min.	108	22	13	9.9	9.7
Rapid mix—60 min.	118	29	8	9.5	19.4

TABLE 2

Summary Showing Second-Stage Mixing

	Total Hardness	MO Alkalinity	P Alkalinity	pH	Mg
Slow mix—20 min.	104	30	21	10.0	9.7
Add $CaCO_3$ and slow mix Additional 20 min.	74	15	3	9.3	8.7
Slow mix—60 min.	92	24	10	9.6	8.7
Add $CaCO_3$ and slow mix Additional 60 min.	74	18	1	9.3	7.8

TABLE 3

Summary Using Calcium Carbonate Slurry

	Total Hardness	MO Alkalinity	P Alkalinity	pH	Mg
Blanket contact—3 ft.	163	100	87	10.5	8
Blanket contact—9 ft.	150	106	96	10.5	8
Slow mix—20 min.	63	25	3	9.5	8
Slow mix—60 min.	62	25	3	9.5	4
Rapid mix—20 min.	48	25	1	9.5	8
Rapid mix—60 min.	49	20	0	9.5	4

Note: Results calculated in terms of calcium carbonate, except magnesium. Results are a average of a long series of runs using the same tap water.

(3) Another jar was likewise used except that the contents were given rapid agitation for the same periods as used in the slow mix tests.

The results of the series helped to show the relative merit of each step in water-stabilization processes that utilizes contact between the solid and solution phases.

Discussion

In general, the results of the series demonstrated that blanket contact alone gave the least stabilizing effect, that slow mixing gave much better results and that rapid mixing gave the best.

It was demonstrated that increasing the length (time) of travel of water flowing upward through the slurry blanket had little effect in reducing alkalinity and pH. Increasing the length of contact time of the slow mix series also showed very little benefits. Increasing the time factor in the rapid mix series, however, showed improvement in the pH and total alkalinity, and the best water were produced in this series.

The mixing series with the magnesium-hydrate-bearing slurry showed tendencies toward an increase in total hardness and magnesium content. The longer the contact period, the greater the pickup in hardness. This may have been due to the production of soluble basic magnesium complex compounds. This was not true of the blanket contact series but at the same time nothing much else happened in this series.

The runs using pure calcium carbonate slurry did not show this pickup in hardness or magnesium.

Prolonged rapid agitation of the mixture of calcium carbonate slurry and the water being treated appears to be the most efficient means of producing a balanced water.

If magnesium-hydrate-bearing slurry is used as the contact media, the hardness of the water will be increased as the pH drops.

Advantages

1. This treatment method yields a truly balanced water at the water temperature of the plant.

2. Recarbonation is not required, which means that the operating staff does not have to exercise the delicate control over CO_2 injection that might be required with other methods.

3. Because of the stabilization effect of the calcium carbonate particles, there is a great deal of tolerance in operation—much more so than when acid adjustment is practiced.

4. This method allows the complete use of the technique of intimate contact between the solid phase of the calcium carbonate and the supersaturated solution of carbonates and hydrates.

5. Eliminating the obnoxious first-stage sludge and recirculating only the second-stage sludge with the finished water has avoided the major disadvantage of slurry recirculation.

6. This method allows the use of short-period sedimentation so that the process is relatively economical of construction.

Disadvantages

1. This method does not remove the magnesium in the split portion and, therefore, the water will contain all of the magnesium existing in approximately 25 per cent of the supply. However, the water would have to be exceptionally high in magnesium for this to be of any great significance.

2. Where alum is used as a coagulant in the second stage there is a possibility that a "milky" water may be produced. This disadvantage, if true, would apply to any form of recirculated slurry operation technique.

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **34:** 412 (Mar. '42) indicates volume 34, page 412, issue dated March 1942. If the publication is paged by the issue, **34:** 3: 56 (Mar. '42) indicates volume 34, number 3, page 56, issue dated March 1942. Initials following an abstract indicate reproduction, by permission, from periodicals, as follows: *B.H.—Bulletin of Hygiene (British); C.A.—Chemical Abstracts; P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (British); I.M.—Institute of Metals (British).*

POSTWAR PROBLEMS AND PLANNING

Postwar Manpower Problems. MORRIS S. VITELES. Edison Elec. Inst. Bul. **12:** 1: 15 (Jan. '44). Gigantic task at start of war of transferring 10 million men from industry into armed forces and reshuffling workers in industry to provide material needs of these forces must be re-enacted in reverse after war. Task of re-establishing men from armed forces augmented by problem of returning about 20 million war workers to civilian production. Whole procedure involves reshuffling of approx. 30 million jobs. Industry's obligations to ex-servicemen duly established under Selective Training and Service Act of '40. Act also provides that private employers who fail or refuse to comply with its provisions may be compelled to do so by federal dist. courts, which can also order compensation for any loss of wages or benefits suffered by ex-servicemen refused employment. Extensive mchy. set in motion through numerous agencies to make good Congressional promise of jobs for ex-servicemen. Planning has been on natl. and even global scale. Gray, Studebaker and many other plans looking to natl., state and local action to facilitate both replacement of discharged military personnel and reshuffling of employment situation in general. Such large-scale planning necessary but effectiveness with which ex-servicemen suitably employed in industry not primarily function of postwar planning on natl. scale but rather dependent on extent to which each plant prepares for re-employment and adjustment of men returning to work on individual and understanding basis. If each company does its own planning for finding appropriate jobs for its veterans, basic manpower problems of postwar era can largely be solved without extended intervention of complex organizations and meddlesome bureaucracies which frequently serve to confuse rather than to resolve problems. From viewpoint of placement in company organization, men returning from military service can be divided into 3 groups: (1) Those who want to and are physically able to go back to their old jobs. (2) Those who have received tech. training and whose war experiences have been such as to create dissatisfaction with job held before entering military service and who expect a better or more responsible job. Desirable in interests of men and company to use to max. skills and experience of men returning from military service. (3) The physically disabled. First trickle of what will develop into a considerable stream of disabled veterans already returning to community. Employers must share responsibility for placement of these handicapped individuals. 3 general steps to be taken by any company interested in prepg. in advance for placement of employees returning from military service: (a) Survey of company's occupation picture in order to spot those jobs which can most easily be made available to those returning from service, including those in which physically handicapped can be used. (b) Organize plan for occupational counselling of men returning from military service such as is already being made by Army, Navy, Selective Service System and other govt. agencies. This plan can accomplish more if conducted on plant or company basis. Objective will be to ascer-

tain occupational assets, liabilities, interests and preferences of the man and find job in organization which can use these to best advantage. Special aids prepd. by Div. of Occupational Analysis and Manning Tables, Washington, D. C. Information designed to facilitate max. utilization in civilian occupations of individual's occupational experience secured while in Army or Navy and to promote effective utilization of abilities and skills of those discharged with phys. handicaps. (c) Provision for a training program which may be necessary to help adjust the man to job selected for him. This will involve refresher training for men returning to their old jobs and indoctrination and more extensive training for men assigned to new jobs. Employers should recognize importance of establishing plans in their own organizations now for postwar employment, as it is here that most effective results will be gained.—*H. J. Chapton.*

Presidential Address: Increasing Consumption of Water. S. R. RAFFETY. Wtr. & Wtr. Eng. (Br.) **46:** 240 (June '43). (*Abstracted*, Jour. A.W.W.A. **36:** 225 (Feb. '43).) *Discussion.* Surveyor (Br.) **102:** 321 (July 30, '43). G. HOWARD HUMPHREYS: Surest way in which waste likely to be prevented is to make everyone pay for water in proportion to what they use. Metering would have most beneficial effect so far as curtailing consumption is concerned. Other devices for curtailing waste: (1) fixing of foot-operated sprays to all hand basins; (2) introduction of efficient hot and cold mixing valve as std. bath fitting; (3) provision in domestic hot water systems of storage heater at kitchen sink; and (4) provision of bowl-type urinal in every house. Wisest course would be to cut out all water wastage in houses and deal with flushing of sewers and diln. of sewage as separate problems. *Ibid.* **102:** 326 (Aug. 6, '43). H. D. MANNING: Introduction of metering would be mistake both on broad principles and economic grounds. Attack on waste should be by installation of improved san. fittings and education and propaganda on use of water. Has Humphreys allowed for cost of fitting 10 million meters at, say £3 each and cost of reading only twice a year, say 2000 inspectors at £250 per annum? Bathers seem to fall into 2 categories—those who fill first and adjust temp. afterwards, and those who start sitting in empty tub and adjust temp. as it fills. As confirmed member of latter group, I should find mixing valve an insult to my skill. *Ibid.* **102:** 337 (Aug. 13, '43). W. H. NEWTON: Metering of all water supplies should become std. practice. Water should be charged for at price high enough to discourage waste. Water wasted through badly designed hot water systems, and should be compulsory to place bathroom in such position that length of circuit reduced to min. Water wasted in watering gardens. Provision of tank to collect rain water from roof should be provided in all new houses. Household sinks, 10″ or more in depth, should be prohibited as undoubtedly water wasters. Spring faucets should prevent much waste. GEORGE BAXTER: Humphreys would like, in anxiety to save water, to revert to days of Tudors. He exaggerates water wastage in domestic service. Water should be treated differently from gas and elec.; they can be done without. Also public health aspect. Domestic metering for city of 500,000 would cost about £600,000, to say nothing of annual cost. All question of cost and where water plentiful and cheap game not worth candle. Where excessive waste in any community, fault lies with water works authority. J. H. NICHOLSON: Research should be directed towards design of self-closing taps and other measures which have, in past, been frowned upon. Metering of domestic supplies surest safeguard against waste. Sterner attitude towards users of hoses for car washing and garden watering of benefit. H. R. L. STRAWBRIDGE: More practical and economical solution of hot water saving would be installation of secondary circuit insuring immediate hot water at all points of drawoff. *Ibid.* **102:** 430 (Oct. 22, '43). F. R. DINNIS: Effect of pressure in distr. mains on rate of drawoff and loss due to leakage appears to have been overlooked. Found from practical trials with pressure of 40 psi., 24-hr. consumption, 78,000 gal. When pressure raised to 100 psi. consumption was 177,000 gal. Higher consumption in Scotland and northern counties partly due to higher pressures. *Ibid.* **102:** 445 (Oct. 29, '43). HARRISON SIMPSON: Tap should give 58% more discharge under 100 psi. than under 40 psi. Difficult to reconcile theory with practice in this case. NORMAN GREEN: Pressure-reducing valves will be means of saving large quants. of water. Recent urgent request for water met by by-passing pressure-reducing valves. Within few days found that ball cocks could not shut off supply; also water hammer caused during night. Many

instances where metering of supplies not means of checking wastes. *Ibid.* **102:** 507 (Dec. 3, '43). R. J. LEWIS: Simpson's formula (from which his figures obtained) does not apply to problem, especially with regard to min. night flow. With small initial night waste, increase in pressure accelerates waste and large proportion of ball taps will commence discharging.—*H. E. Babbitt.*

Water Supply to Housing Schemes and Planning. S. R. RAFFETY. Wtr. & Wtr. Eng. (Br.) **46:** 433 (Oct. '43). First consideration is site of proposed houses. In most cases ground available at elevation not suitable for water supply from existing works; necessitates booster pumps. Com. asks water engr. what size water pipe will be required for plan. Use of following formulas will give answer without much calcn. Veloc. of 3 fps. for water travelling in pipes common. Hence, $Q = d^2$ where Q is cfm. and d is diam. of pipe in inches. $N = 20d^2$ where N is no. of houses at 5 persons per house, each person taking 40 gal. (Imp.) in 12 hr., and $H = \frac{5}{d}$ where H is head loss in ft. per 100′ of main. 30 psi. on water mains laid under streets suitable for most domestic purposes. Prewar working cost of pumping 1000 gal. (Imp.) 100′ high was 1d. As regards postwar planning, no lead given water engr. how to provide adequate water supply.—*H. E. Babbitt.*

Water Engineering After the War. N. A. F. ROWNTREE. Wtr. & Wtr. Eng. (Br.) **46:** 451 (Nov. '43); Jour. A.W.W.A. **36:** 12 (44); *Editorial Notes.* Wtr. & Wtr. Eng. (Br.) **47:** 7 (Jan. '44). Author spoke of special difficulties likely to be encountered in postwar period, particularly great danger that water works might become subject of political conflict. Elliot said ½ of water works in United Kingdom supplies pops. under 5000. Solution would lie in amalgamation of rural and urban works. Boswell believes water works would be controlled for some time to come by existing labor and material "controls." Davies foresees shortage of qualified water engrs. in postwar period. Too high proportion of only partly trained men occupying responsible posts in water works today. Council of Inst. of Water Engrs. decided on Dec. 2 to set up com. to exam. whole question of water works after war. Most noticeable feature in connection with mass of plans being produced is ardent interest in planning. Different from last war. Inst. of Civ. Engrs., in conjunction with Inst. of Munic. and County Engrs., organized elaborate Practical Planning Exhibition held from Oct. 5 to 30. In Inst.'s own words they "are attempting to put before public postwar planning viewed from definitely different angle, though central object remains same—improvement of avg. citizen's environment in new world which will begin its existence as last notes of 'Cease Fire!' echo through shattered Europe." Some problems to be tackled: (1) proper utilization of land; (2) execution of land drainage schemes; (3) regional water supply; (4) regional sewage disposal; (5) health and utility services; and (6) district heating. *Discussion.* Surveyor (Br.) **103:** 17 (Jan. 14, '44). ANON: Announcement of formation of com. to consider eng. aspects of water supply after war welcome. Water supply almost unique among public services in that no amt. of planning by man could affect varied distr. and fluctuating supplies of raw material. Elliot put forward powerful argument for change to public ownership in those cases where it would enable necessary amalgamation to take place. Adjacent local authorities not always ready to sink identities to enable water board to be formed. Inst. of Water Engrs. could collect hydrological data through junior members who could act as collectors and abstractors of available data. Wood thought that by intelligent and interesting publicity in time of plenty, public might become more amenable to requests for special economy in times of drought and emergency. Appalling ignorance by public of means by which pure water supplied. Since Sept. '43, 35 lectures given to over 1000 women and many more bookings allocated for '44. Incumbent upon engrs. to minimize cost of rural schemes by new methods of design, production and installation. Author could not disagree with Risbridger when he said that regional officers of Ministry of Health, acting as beneficent liaison officers, could be of assistance, but felt some danger that "liaison" might become "interference," and more dangerous, "interference without responsibility."—*H. E. Babbitt.*

Water Engineering. ANON. Surveyor (Br.) **103:** 31 (Jan. 21, '44). Future of supply undertakings, river boards, resources, dams and embankments, silting of reservoirs, purif., distr. system and waste prevention. Brief notes of events of '43, together with references to some water works articles in U. S. publications.—*H. E. Babbitt.*

BACTERIOLOGY

Observations on Bacteriological Condition of Creamery Water Supplies. H. F. LONG & R. T. CORLEY. (*Published in abstract only.*) J. Bact. **44:** 255 (Aug. '42). Tests of 70 creamery water supplies included examn. for *Escherichia-Aerobacter* species by enrichment in lactose broth and tryptose lauryl-sulfate broth; total counts on beef extract and tryptone, glucose, extract, milk agars at 37°C.; total proteolytic and lipolytic counts on tryptone, glucose, extract, milk agar at 21°C.; examn. for *Pseudomonas putrefaciens* by culturing on special gelatin medium after enrichment in litmus milk at 3°C. and washing butter granules churned from thoroughly pasteurized cream with the water, and testing keeping qualities of unsalted butter at 21°C. Approx. half of supplies unsatisfactory as indicated by production of defects in unsalted butter or *Esch.-Aer.* content. Most unsatisfactory supplies represented water originally from plant wells although some city supplies involved. Frequently, water taken directly from well satisfactory while that from churn not; contamn. evidently in storage tank or piping.—*Ralph E. Noble.*

Vegetable Bacteriological Media as Substitutes for Meat-Infusion Media. JOHN H. BREWER. J. Bact. **46:** 395 (Oct. '43). (*Published in abstract only.*) From vegetable (veg.) material alone, namely, cotton seed, peanut and soybean meals, various whole and sprouted grains, beans and seeds, author prepd. media equal to or more satisfactory than meat-infusion peptone broth or agar as gen. culture media. Satisfactory method used: meal, 650 g.; papain, 30 g.; Na_2S, 5 g.; and water, 4000 ml. Dissolve papain in about 500 ml. of water. Dissolve Na_2S in 100 ml. of water, add to papain soln. and let set 15 min. Then add papain soln. to veg. meal and water mixture, adjust to pH 5 with HCl and incubate overnight at 37°C. Clarify by filtration, adjust filtrate to pH 7.6, heat to boiling and filter. Medium then distributed, autoclaved, stored and dild. as used. Yield of concd. medium about 3500 ml. contg. 7–10% total solids. For use, dil. to 14,000 ml. and add 0.5% NaCl, giving finished broth contg. 2–3% solids. Cost only fraction of that of meat-infusion broth, and peptone not required. Auto-digests made by omitting enzyme. For some specific purposes, sprouted seeds and bean digest found superior to ungerminated plant material digests. Different veg. materials vary in growth-promoting properties, most satisfactory single source probably being soybean meal. For gen. purpose media, however, soybean and cotton-seed or peanut meal recommended. Veg. media grow many streptococci, pneumococci, gonococci and other fastidious organisms without serum or other growth-promoting factors. Not found true for acid digests, peptic or pancreatic digests of same veg. materials. Colony size on plant agar much greater than when meat-infusion used. Very potent toxins produced. When veg. media used as base for fluid thioglycollate medium, *Clostridium novyi* and *Cl. tetani* grew in dilns. as high or higher than either thioglycollate formulas used as std. sterility test media for biol. products. Most butyric organisms failing in veal infusion, grow on this medium. Water and milk counts made in veg. agar invariably higher than in Std. Methods agars. Generally, numbers per ml. in veg. broth greater than in infusion broth.—*Ralph E. Noble.*

The Differentiation of Human and Chicken Strains of *Escherichia coli* on the Basis of Phenol Tolerance. J. M. LEISE & L. H. JAMES. (*Published in abstract only.*) J. Bact. **45:** 99 (Jan. '43). Human and chicken strains of *Esch. coli* isolated from fecal matter respectively and growth curves obtained by growing strains in phenol-contg. broth. Results with elec. nephelometer showed chicken strain more resistant than human. Greatest difference obtained at phenol diln. of 1 : 525. Using second set of freshly isolated strains of both types, growth curves established with plate counts. Results checked first set to same diln. To inhibit weaker human strains further while allowing chicken strains to grow, former cultured twice in phenol-contg. broth. Phenol dilns. of 1 : 520 and 1 : 525 completely inhibited 3 of 4 human strains while only 1 chicken strain failed.—*Ralph E. Noble.*

The Detection of Water-Borne Organisms Causing Bacterial Deterioration of Butter. R. H. N. TREMBATH. J. Australian Inst. Agr. Sci. **8:** 150 ('42). Use of dimethyl-*p*-phenylenediamine, as suggested by method of Castell (C.A. **35:** 2225), for detecting organisms which produce defects in butter has too wide a range for any individual examn. to have definite qual. signif. Use of slightly modified

Linneboe's ferric ammonium citrate agar medium (C.A. **35:** 2622) reveals marked correlation between characteristic pitting of medium and development of "surface taint" defect in exptl. butter. Modification consists of using lactose agar medium instead of nutrient agar and adjusting pH to 6.8–7.0 instead of 7.2–7.5. Transfer of suspected colonies to litmus milk increases reliability of differentiation.—*C.A.*

Bacteriology of Ice. L. B. JENSEN. Food Research **8:** 265 (July–Aug. '43). In nature, water usually frozen into ice-I. Of 6 ice varieties, only ice-I can exist under pressures much less than 2000 atm. Ice crystallizes in hexagonal system. Super-cooled water may exist in quickly chilled beef or when drops of water quickly chilled to −12°C. (10.4°F.) or lower. This may be water condition when molds and bacteria grow on meat at −8 to −12°C. (17.6–10.4°F.). Ice crystals grow as water freezes, and water layer more impure than original water surrounds crystals. Thus, each crystal enclosed in lower melting point material than itself as proved upon melting. Crystals then become more and more separated and ice becomes "rotten." Melting always begins at boundaries between crystals. Bacteria, particulate matter, and dissolved substances may be extruded or redistributed in ice during these changes. Perhaps bacteria destroyed between growing crystals. Crystallization rate, density, viscosity, etc., tend to influence distr. of trapped substances. Ice harvesting must follow "instructions" based upon bact. criteria. After storage several mo., non-sporing bacteria greatly reduced. Sanitarians consider ice unimportant factor in typhoid fever spread. Genera found in newly harvested lake and river ice: *Pseudomonas, Spirillum, Chromobacterium, Acromobacter, Serratia, Aerobacter, Proteus, Bacillus, Cellulomonas, Flavobacterium* and *Micrococcus.* Bacteria in ice destroyed more readily at natural ice temps., 0 to −5°C. (32 to 23°F.). At lower temps. down to liq. air, bacteria-like typhoid remain viable 19 mo. or longer. Several kinds of germicide treated ice used under exptl. conditions. Benzoates and nitrites show promise for icing certain foods.—*Ralph E. Noble.*

The Increased Resistance of Aerobacter Aerogenes to Sodium Pentachlorophenate. B. F. SHEMA & JOHN W. APPLING. J. Bact. **45:** 573 (June '43). Authors studied acclimation of 11 single cell isolates and parent *Aerobacter aerogenes* to pentachlorophenate. Characteristics of each isolate and parent detd., using 31 different criteria. Each typical *Aer. aerogenes* according to Bergey. To det. point of inhibition (no visible growth on slant) for each culture, nutrient agar contg. various increments of Na pentachlorophenate prepd. Increment 0.005% by wt. Each concn. for each culture replicated 4 times. Each slant inoculated with 7 mm. loop and incubated at 37°C. 1 wk. In no case did inhibition point exceed 0.04% by wt. As all cultures grew at 0.01% concn., transfers made from this as initial point to next highest. Each week, pooled inoculum from replicates transferred to next succeeding concn. increased by 1 increment. Survival-concn. incidence given. 3 still growing at 0.215% concn. At intervals, isolates checked by all previous criteria. Generally remained true to form at low concns. The 3 high concn. survivors began showing differences at 0.175%. One no longer formed gas from arabinose; another none from rhamnose. M.R. test became pos. for 2. V.P. reaction doubtfully pos. in all 3. Cells larger than normal. When cells about to fade out, generally become filamentous. When regrown on nutrient agar for several generations, gradually become shorter and approach normality.—*Ralph E. Noble.*

The Importance of Bacteria in Water Supply and Sewage Treatment. C. P. MOM. Dtsche. Wasserwirtschaft (Ger.) **4:** 211 ('41); Wass. u. Abwass. (Ger.) **39:** 111 ('41). Author describes action of bacteria in soil on water percolating through soil at various depths. A similar action, which can be greatly accelerated by suitable design, takes place in slow sand filters used for treatment of water. Deposition of layer or film on surface of filter may increase bact. activity but may hinder passage of water through filter. Improved action obtained by adding to sand layer of active carbon; by adsorbing dissolved org. matter and bacteria, active carbon insures close contact between bacteria and their food. Action of bacteria in purif. of sewage discussed. Org. matter can be rapidly oxidized by air in flowing water but in still water oxygen supply may become depleted and bact. activity may cease. In treatment of sewage in percolating filters or by activated sludge process, bacteria kept in such close contact with air that they accomplish as much destruction of org. matter in a few hours as

would take place under natural conditions in as many weeks. Hygienic importance of aerobic bacteria must not be underestd.; in activated sludge process bacteria of typhoid, cholera and dysentery may be destroyed. Sludge from sewage can be rendered unobjectionable by anaerobic digestion, producing an odorless humus and evolving gas of high heating power.—*W.P.R.*

Comparative Data on the Determinations of the Total Number of Bacteria in Water. N. R. DYADICHEV. Lab. Prakt. (U.S.S.R.) **16:** 10, 11: 11 ('41). Studies made on bact. growth in water suitable for drinking according to physico-chem. examn. (**I**); in river water before poln. by sewage water (**II**); in river water after being pold. by sewage water (**III**); and in fecal sewage water (**IV**). For **I** avg. growths in agar-agar, 440 and 112 colonies at 22° and 37°, resp. Indirectly these data indicate presence of saprophyte microflora in **I** with optimum growth considerably below 37°, which may not be connected with contamn. with human and animal wastes. For **II** avg. growths in agar-agar, 1490 and 500 colonies at 22° and 37°, resp.; for **III**, 4700 and 2050 colonies; for **IV**, 207,920 and 222,460 colonies. In **II**, growth at 22° in winter decreases by 50% of that in summer and by 80% at 37°. In summer no. of bacteria growing at 37° nearly 50% of that growing at 22°. In remaining seasons of year, growth at 37° is from $\frac{1}{7}$ to $\frac{1}{3}$ of that at 22°. Percentage ratio between growth at 22° and 37° in **II** remains practically unchanged during year. Seasonal variations in no. of bacteria depend chiefly on temp. of water and decrease or increase in microflora added to water.—*C.A.*

The Saving of Agar by the Use of Combined Agar-Silica Gel Plates. G. RAUCH. Arch. f. Hyg. u. Bakt. (Ger.) **130:** 57 ('43). Expts. performed with media solidified with silica gel in hope that saving of agar might thus be effected. Silica media alone so friable that surface could not be inoculated without breaking it, and media ultimately recommended consist of 2 layers, of which lower contains 10 ml. of silica medium and upper contains 7 ml. of 1.2% nutrient agar. Calcd. that 80% of agar saved by using these plates instead of usual 2%. Details given of prepn. of medium as base for selective and differential intestinal media and for blood plates. Yeast extract could be used in place of meat extract and peptone. Sodium sulfite said to increase growth of organisms in silica media and, although author could not confirm this, includes it in formula. Accumulation of condensation water liable to be troublesome and, in preference to using paper-felt strips impregnated with calcium chloride, author dries plates for some hours in incubator at 40–50°C. Media gave satisfactory results in respect of bact. growth, agglutinability of colonies, pigment production and zones of haemolysis.—*B.H.*

Further Studies on the Eijkman Reactions of Shigella Cultures. C. A. STUART & ROBERT RUSTIGIAN. J. Bact. **46:** 105 (July '43). In work on 276 cultures, 45°C., ±0.1°C. most satisfactory incubation temp. 86 cultures of 5 types (*Shigella dysenteriae, paradysenteriae, ambigua, sp.* (Newcastle), and *equirulis*) comprised Group I, while 190 (*Sh. sonnei, alkalescens, dispar* (madam pensis), and *ceylonensis*) comprised Group II. Inoculations made with Difco Eijkman medium base with glucose and incubated 24 hr. None of Group I grew. After 24 hr., placed at 37°C. After showing no visible growth in from 12 to 36 hr., 79 produced acid, 7 failed to grow. All 190 Group II cultures grew and 185 (97.4%) produced strong acid from glucose at 45°C.—*Ralph E. Noble.*

The Unsterile Phase in the Removal of Iron From Water. P. KEIM. Arch. f. Hyg. u. Bakt. (Ger.) **129:** 1: 209 ('43). Well water in Hamburg dist. free from bact. poln. but contains quants. of iron and manganese which must be removed by aeration with compressed air and filtration through gravel. Iron sludge removed by washing gravel with water. Enormous no. of bacteria found in sludge and yet effluent from plant free from bacteria. Concluded that bacteria introduced in compressed air (for in works not employing compressed air no unsterile phase occurs) and removed by adsorption on colloidal iron, which eventually ppts. Suggested that collodial iron hydroxide acts as bactericidal agent in addn. to its sedimentation action.—*B.H.*

The Metabolism of Coliform Bacilli in Distilled Water. JOSEPH W. BIGGER & J. HAVELOCK NELSON. J. Path. & Bact. **55:** 321 (July '43). Expts. prove that coliform growth in distd. water contg. talc due to dissolved atmospheric CO_2 and NH_3. Not

known whether actual nutrient material used is ammonium carbonate, $(NH_4)_2CO_3$, formed from the 2 gases. Fact that growth occurs in ammonium carbonate solns. does not support theory strongly as salt dissociates in soln. as does Na bicarbonate. Talc role obscure. When $(NH_4)_2CO_3$ substitutes for gases, talc unessential but useful in making salt concn. less critical, possibly acting as buffer to absorb inhibitory excess of either gas when both used. If true, growth should have occurred occasionally without talc exposed to air, but many times did not. Probable by some surface action talc renders either CO_2 and NH_3 or $(NH_4)_2CO_3$ more readily available as food. —*Ralph E. Noble.*

Relative Resistance of Coliform Organisms and Certain Enteric Pathogens to Excess-Lime Treatment. ELSIE WATTIE & C. W. CHAMBERS. Jour. A.W.W.A. **35:** 6: 709 (June '43). Study of literature of excess-lime treatment of water suggests that it might be substituted for chlorine sterilization without marked loss in bact. eff. Accordingly, tests made to det. bact. eff. of excess lime on common water-borne pathogens and coliform organisms. Results indicated that, given sufficient time for contact, waters could be made bacterially safe with excess lime. Death rate of all strains tested increased with higher pH ranges. Pathogens more easily killed than non-pathogenic organisms. Disinfection of pathogenic organisms, however, slow process. For example, in pH ranges 9.51–10.0 and 10.01–10.5, 100% kill of *Bact. typhosum* not obtained during 6-hr. contact period. In fact, exposure of 2 hr. at room temp. to pH of 11.01–11.50 or of 4 hr. to pH of 10.51–11.0 required to sterilize suspension of *Bact. typhosum.* [Possible explanation of slow rate of sterilization may be found in nature of suspending medium employed for tests; this consisted of de-chlorinated autoclaved tap water. Well known that water chlorinated (and then neutralized) or autoclaved, better able to support bact. growth than water in natural state.]—*C.A.*

Differentiation Between Members of the Genus *Vibrio* by the Bactericidal Technique. J. GORDON & K. I. JOHNSTONE. J. Path. & Bact. **54:** 221 (Apr. '42). Bactericidal technique can be used for detecting antigenic differences between members of genus *Vibrio* because of their marked sensitivity to bactericidal action of normal guinea-pig serum. Method limited in practical application because of difficulties in adjusting absorption, inoculation and complement titer of several sera simultaneously. Antigenic differences detected between true cholera strains and related vibrios; also distinguished certain *V. cholera* strains differing antigenically from main group. Technique may differentiate between *V. cholera* strains for which agglutination technique impractical, and as alternative method to haemolytic test for distinguishing between *V. El Tor* and true cholera.—*Ralph E. Noble.*

The Effect of Bacteriophage on the Variability of Intestinal Bacteria and on Their Determination in Water. A. E. KENINA. Z. Mikrobiol. Epidemiol. Immun. (U.S.S.R.) *No. 9:* 68 ('41). Neglect of effect of bacteriophage on intestinal bacteria may lead to erroneous evaln. of drinking water. Bacteriophage exerts observable effect within 5 min.; effect is max. on 2nd day. On 3rd, 4th and 12th day appears secondary growth of morphologically and biochemically atypical forms. These frequently restored to normal by further culturing on agar-agar, inoculation on Endo medium and passing through bile. Takes longer to obtain colonies of intestinal bacteria from water that contains bacteriophage than from phage-free water. Citrates added to liquid and solid media retard lysing effect of phage. In no. of expts. possible to sep. intestinal bacteria by inoculating water on Eijkman medium. Phenomenon observed in investigations of water from open reservoirs. —*C.A.*

Bacterial Activities in the Subaquatic Soils of Lake Erie. WM. C. BEAVER. Ohio J. Sci. **42:** 91 ('42). During summers of '39 and '40, bact. study made of bottom soils of L. Erie and tributaries. Samples collected with dredges. Reduction of urea to NH_3 observed in every sample in all stations tested. Oxidation of NH_3 to nitrites strong in 12 stations, moderate in 7, slight in 27 and neg. in 9. Oxidation of nitrites to nitrates only slight in 15 stations and neg. in 40. Reduction of nitrates to nitrites, to NH_3 and to N showed strong production of NH_3 in 24 stations and moderate production in 31. Balance between nitrate formation and nitrate reduction in favor of latter. Presence of nonsymbiotic free N-fixing *Azotobacter* organisms demonstrated in each of 55 stations. Cellulose-digesting organisms found in some stations. H_2S varied from strong to none.—*C.A.*

Bacterial Aftergrowths in the Distribution System. A. B. JEWELL. Southwest W.W.J. **23:** 13 (Feb. '42). Bacterial aftergrowth, as defined in article, limited to mean "increase in bacterial content of a water occurring in distr. system from causes other than poln. subsequent to treatment in plant." 3 conditions must be present if bacterial aftergrowths to occur: infecting organisms must be present; must be suitable food supply for growth; and growth-inhibitory substance in appreciable quants. must be absent. Pointed out that if food supply not available, no bacterial aftergrowths. To do away with food supply, suggested that "dead ends" in distr. systems be expurgated. Chlorination of high concn. will help. Available evidence does not indicate that bacterial aftergrowths themselves constitute health hazard; but inability to discriminate among coliform organisms necessitates regarding their presence in distr. system with suspicion and should not be dismissed as merely bacterial aftergrowths. In using coliform index as criterion for detg. san. qual. of water system, caution must, therefore, be exercised to interpret signif. of coliform organisms which may occur in distr. system.—*P.H.E.A.*

Status Selective Service Registrants

At the Senate Military Affairs Committee hearing May 18, on work-or-fight legislation, it was disclosed that on May 1, the 22,216,807 selective service registrants from 18 to 37 yr. old were grouped as follows:

Classification	*Total*	*Non-Fathers*	*Fathers*
Total living registrants	22,216,809	15,468,452	6,748,354
I-C. Furnished to the armed forces (this does not include non-registrant enlistees who were under age or over age at time of enlistment, or who were women; it does include a certain number of registrants who died or were discharged for disability following induction)	9,908,277	9,503,110	405,167
IV-F. Disqualified from service with the armed forces for physical, mental, educational or moral reasons	4,048,914	3,340,270	708,644
I-A. In process of classification, examination and induction	2,348,075	809,153	1,538,922
Unclassified	81,414	81,414	....
II-A. Deferred as engaged in war-supporting activity	1,325,792	203,828	1,121,964
II-A (L) and II-A (F). Engaged in war-supporting activity and not qualified for gen'l military service	3,845	1,553	2,292
II-B. Deferred as engaged in war-production program	2,232,039	549,980	1,682,059
II-B (L) and II-B (F). Engaged in war-production program and not qualified for gen'l military service	5,355	3,013	2,343
II-C. Deferred as necessary in agriculture	1,001,898	672,079	329,819
II-C (L) and II-C (F). Engaged in agriculture and not qualified for general military service	5,148	4,029	1,155
III-A. Deferred for dependency	340,464	14,328	326,136
III-C. Deferred for dependency and necessary in agriculture	655,153	120,964	534,189
III-D. Deferred for dependency hardship	107,002	46,896	60,706
IV-B, C, D, E. Deferred by law (public officials, neutral aliens, ministers, ministerial students and conscientious objectors)	145,333	111,318	34,015
Other and unknown	7,463	6,517	946

War Production Board

Office of Manpower Requirements

ADVICE TO EMPLOYERS REGARDING SELECTIVE SERVICE PROCEDURE *

MAY 2, 1944

Editorial Note: Wherever this statement is in disaccord with the statement issued by the Director of Selective Service, the Selective Service memorandum governs, because of its later date. The constant revisions in the Selective Service policies have made it almost impossible for this JOURNAL to carry recent advice concerning the deferment of necessary men in water utilities. As an illustration, this document supersedes one dated April 27, which had already gone to the printer for inclusion in this JOURNAL. Therefore, the readers of this JOURNAL must be prepared to find the material here published obsolete within ninety days of its publication. We cannot expect Selective Service procedure to be static under 1944 conditions.

THE War Production Board has received literally thousands of letters from employers requesting advice and assistance in dealing with Selective Service procedures. In a great many cases, the writer reveals that he is not acquainted with the various steps involved in requesting deferment for key employees and, as a consequence, has not taken advantage of the procedure established by the Selective Service System for handling deferment requests on a local basis.

These procedures, which are outlined below, should be observed by an employer who finds it necessary to request occupational deferment for key employees. It must be emphasized that the War Production Board cannot undertake to assist in urgent cases until all local avenues of relief, as described in this memorandum, have been exhausted. The employer is of course privileged at any time to consult WPB field offices regarding Selective Service problems. It should also be remembered that an occupational deferment is granted by the Selective Service for only one purpose—to allow time to train or obtain a replacement. The status of important cases is weakened if the employer has a record of presenting trivial cases or if the request for deferment of irreplaceable employees is accompanied by requests for consideration of employees whose essentiality is doubtful.

Bases for Occupational Deferment

Instructions issued to State Selective Service Directors and local Boards by the National Selective Service Head

* INFL-484 Revised.

quarters specify in considerable detail the types of cases in which the Local Boards must give careful consideration to requests for occupational deferment. The bases for occupational deferment are as follows:

1. *Essential Occupations.*—Selective Service has adopted as a guide to deferment consideration the activities and occupations which have been listed by the War Manpower Commission as essential. The list of essential activities embraces virtually all of the manufacturing industries contributing directly to the war effort and a great many activities necessary to the civilian economy. For each of these activities a selected list of essential occupations is specified. Employment in an essential occupation and industry does not lead automatically to draft deferment; it merely establishes a presumption that temporary deferment may be considered while the employer trains or seeks a replacement. Essential activities and occupations are listed in Selective Service Activity and Occupation Bulletins which may be consulted at any Local Board Office.

2. *Critical Occupations.*—Certain occupations have been listed by the War Manpower Commission as critical in recognition of the importance of these jobs in war production. To be considered critical, an occupation must be one in which a shortage exists and one of a highly skilled nature, requiring an extensive period of training. Local Boards have been instructed to give special consideration to requests for deferment of men employed in critical occupations in any of the activities classed as essential. The list of critical occupations, with a brief definition of each job title, is contained in Local Board Memorandum No. 115 which also may be consulted at any Local Board Office.

If the employer feels reasonably certain that an employee, age 26 through 37, who has been classified in 1-A is qualified for and actually engaged in a critical occupation, he may file an affidavit to that effect with the Local Board. (See reference below to procedure for requesting deferment of employees, ages 18 through 25 years.) The case will then be treated in the following manner:

a. If the Local Board is satisfied that the registrant is qualified for a critical occupation but is not entitled to deferment on the basis of his present job, the matter must be referred to the local office of the United States Employment Service for investigation.

b. After such reference, the Order to Report for Induction will not be issued for 30 days or until the United States Employment Service reports on the case.

c. Within the 30-day period, the United States Employment Service office will investigate the registrant's duties and qualifications and may either certify to the Local Board that the man is employed in a critical job or arrange for the transfer of the man to another employer where his qualifications are fully utilized in a critical job.

d. If the Local Board receives no notification from the United States Employment Service, it may reclassify the registrant into a class available for service.

e. Upon receipt of certification that the registrant is at present employing his highest skills in a critical job, the Local Board will reconsider his classification.

Many employers have found it advisable to consult in advance with the occupational analyst in the local Em-

ployment Service office regarding the jobs which are considered to be critical. In this manner the employer may be able to expedite consideration of these cases by furnishing a certification from the Employment Service office when the affidavit is filed with the Local Board.

3. *Contributory Occupations.* — In order to reduce turnover and to provide specified periods of deferment for men currently disqualified for any military service or qualified for limited military service only, Selective Service has provided for consideration for occupational classification of registrants ages 18 and over who by reason of their occupation are making a contribution in war production or in support of the war effort.

At present registrants disqualified for military service by reason of physical disability are placed in Class IV-F. Such registrants may now be classified in Class II-A (F) or II-B (F) if they are "making a contribution" in support of the war effort or in war production. Registrants found qualified for limited service only and currently being placed in Class I-A (L) subject to call at any time when needed, may now be considered for classification in Class II-A (L) or II-B (L) if they are "making a contribution" in support of the war effort or in war production.

Request for such deferment is made by filing an up-to-date Form 42 or 42A or other evidence of occupational need, regardless of the registrant's age, and noting on the face of the request the words "Qualified for limited military service only" or "Disqualified for any military service," as the case may be. Registrants so deferred thus acquire a greater stability in their employment than if left in a physically deferred classification subject to recall by the armed forces at any time.

4. *Age Factor and Consideration for Fathers.*—(a) Registrants 18 through 25. No deferment may be granted on occupational grounds except when recommendation is made in each individual case by the State Director or the Director of Selective Service (see below), whether non-father or father.

(b) For registrants ages 26 through 29 the requirements of a "necessary man" will be strictly applied, although fathers normally will be accorded occupational deferment in preference to non-fathers.

(c) For registrants ages 30 and over the "necessary man" requirements will be applied less strictly and fathers will be accorded more liberal consideration for occupational deferment than fathers under 30 and non-fathers, if all other factors are equal.

5. *Other Occupations in Essential Activities*—Local Boards may grant deferment to unskilled workers in essential activities if it can be demonstrated that the local labor shortage is so acute that serious disruption of war production may be created by the withdrawal of such employees in large numbers.

Special Procedures Affecting Registrants Under 26 Years of Age

Selective Service policy prohibits the deferment of young men 18 through 25 years of age, on occupational grounds, except when their necessity and irreplaceability is certified as to each individual by the State Director of Selective Service. The State Director's certification will be given only on presentation of irrefutable evidence of the irreplaceability of the registrant in an activity considered highly critical to the prosecution of the war. Such certification will be made on a Selective

Service Form 42A Special, previously endorsed by a designated Representative of the War Production Board, War Department, Navy Department, Maritime Commission, Office of Defense Transportation, War Food Administration, Petroleum Administration for War, Solid Fuels Administration, Rubber Director, or the War Shipping Administration.

Advice regarding the filing of Forms 42A Special may be obtained from the War Production Board District Managers. *The WPB District Manager will not endorse requests for the deferment of registrants under 22 years of age.* Any employer whose operations are closely connected with a major war production program and whose production will be seriously curtailed if key employees under 26 are withdrawn, should consult his WPB District Manager.

Local Board Procedures

1. *Requests for Deferment.*—The employer who wishes to request occupational deferment for an employee should file an Affidavit—Occupational Classification. In the case of men, 26 years of age and over, use the Selective Service Form 42A, which is filed with the Local Board.

In completing these affidavits, the employer should set forth the exact nature of the employee's duty; the company's efforts to train replacements; the degree of training, skill, and experience required; and efforts made to obtain acceptable substitutes or trainees, through the U. S. Employment Service and other employment agencies. The employer should supply evidence that every other man in the plant has been upgraded to the fullest possible extent and cannot be used on the job in question, and that it is impossible to break down the duties of the job so that less skilled workers could take over.

These forms may be accompanied by references to any official releases or regulations, such as the list of essential activities, the list of critical occupations, and endorsements by a regional War Manpower Commission Director which would validate the company's claim to essentiality. Consult the District or Regional War Production Board officials regarding advice they may be able to furnish the Local Board or the State Director as to the plant's urgency rating.

After the employer has filed the affidavit he is entitled to notice of the subsequent classification action taken by the Board.

2. *Appeals.*—If the request for occupational deferment is denied and the employer is notified that the employee has been retained in Class 1-A, the employer may file an appeal within 10 days after the date of the notice. Any registrant is entitled to request personal hearing if he so desires and if it is felt that the written evidence before the board may not be complete. If the Local Board then reclassifies the registrant of Class 1-A, the appeal is automatically dropped.

The appeal is filed with the Local Board. The employer should consult the Board regarding the forms and procedures to be used.

Attached to each Local Board is a government Appeal Agent whose duties are to appeal from any classification of the Local Board which, in his opinion, should be reviewed by the Board of Appeal, and to suggest to the Local Board a reopening of any case where the interests of justice require. It may be helpful for employers to

consult the Appeal Agent in preparing an appeal.

In the event the Appeal Board affirms the Local Board decision and the employer is convinced that ground exist for further consideration, the case may be brought to the State Director of the Selective Service by the employer with a request for review to determine whether the case should be reopened by the Local Board for reconsideration, or whether appeal to the President by the State Director is warranted. Occupational advisers attached to each State Director's headquarters are available to review occupational cases and advise registrants and employers of their rights as well as their responsibilities.

In the event the State Director declines either to request the Local Board to reconsider or to take a Presidential appeal and the employer has reason to believe the case has not received thorough consideration by the Local and State Selective Service Agencies, then he may send the case to the Director of Selective Service, Major General Lewis B. Hershey, 21st and C Streets, Northwest, Washington D. C., with a request for review. If the assistance of the War Production Board is desired, a copy of the material in the case should be sent to the appropriate Industry Division or to the Office of Manpower Requirements. In all such cases, prompt action is necessary and the following information must be supplied:

(1) Employee's Selective Service classification, date of such classification, previous occupational classification, if any, age and marital status.

(2) Date of appeal and the vote, split or unanimous, of the Appeal Board.

(3) Employee's occupation and detailed description of his duties, including skills and previous training.

(4) The date of induction, if order to report has been issued.

(5) The date of referral to the State Director and the date of his decision.

(6) Complete explanation of employer's effort to train, upgrade, or obtain a replacement. It is the employer's responsibility to exhaust every possible effort to replace men liable for military service under the law.

Selective Service regulations provide that a registrant may not be inducted either during the 10-day period allowed for appeal of his classification, or during the time such an appeal is pending. It is advisable, however, to make sure that the Local Board is aware of the fact that an appeal is pending, especially in the case of an appeal to Selective Service in Washington.

Replacement Schedules

A Replacement Schedule is a reciprocal agreement between Selective Service and the employer that workers will be released at a stipulated rate intended to enable the company to effect replacements without a serious dislocation of its operations. Use of the Replacement Schedule is voluntary, but only those firms whose activities are essential to the war effort may participate. The State Headquarters Occupational Advisory Staff should be consulted to determine whether the Replacement Schedule Plan can be applied to the employer's activity.

The Replacement Schedule consists of three parts:

(1) The Replacement Summary (Form 318), which lists the jobs within each plant, showing for each the total

number of workers, both male and female, and an analysis of the availability of male workers for service in the armed forces.

(2) The Replacement List (Form 319), which shows the individuals by name who are to be released to the draft and the month or period, at the end of which they are scheduled for release.

(3) The Replacement Schedule title sheet (Form 320), which summarizes the number of workers by age groups and indicates the number of releases by months.

Detailed instructions for the preparation and filing of Replacement Schedules are contained in Local Board Memorandum No. 158. Copies may be obtained by writing State Selective Service Headquarters.

Employers dealing with Labor-Management Committees will probably find it helpful to call upon the Committee for advice and assistance in the preparation of Replacement Schedules. While the State Selective Service Director is not required to give weight to the Committee recommendations, he will, no doubt, be favorably disposed toward those schedules in which it is evident that each case has received such careful consideration.

The Replacement Schedule, even though approved by the State Director of Selective Service, does not deprive the Local Board of the authority, subject to the usual right of appeal, to grant or reject requests for occupational deferment. Certified affidavits (Form 42A), bearing the proper State Acceptance Number are, however, expected to be recognized by the Local Boards as evidence that the employer is attempting to release his employees in a systematic manner in accordance with Selective Service principles.

If an employee for whom a request for deferment is being made receives an order to report for induction during the period when a replacement schedule is under consideration by the State Director, the following steps should be taken:

(1) The registrant's Local Board should be notified by phone or telegram that a replacement schedule is pending and asked to suspend action until the State Director has acted on the schedule.

(2) The State Director should be notified of the necessity for speedy action. If the State Director does not approve the entire schedule, he may be asked to intervene in behalf of the individual employee.

National Selective Service Outlines New Draft Instructions

NEW instructions of the National Selective Service to local boards for classifying draft registrants were released from Washington on May 11, 1944.

Men thirty years and over working at war jobs or in activities essential to "national health, safety or interest" will probably not be drafted "for an indefinite period." Previously men in this age group were required to be "necessary" in essential jobs before they were deferred. Men twenty-six through twenty-nine in similar jobs may remain in the civilian class for six months or longer. The terms of the new policy depend upon the need at the war front which at present is for men eighteen to twenty-five.

The new policy gives to local boards broad authority to add to the list of essential jobs as the need arises . . . if they are, in the opinion of the Board, "engaged in activities in support of the national health, safety or interest." Included in such jobs are *utilities*.

Portions of National Selective Service headquarters' memorandum to local boards outlining policies for classifying registrants by age groups follow:

Under these policies, the prospect for registrants ages eighteen through twenty-five is service in the armed forces unless they meet the specific conditions for deferment which have been established by the director of selective service. The prospect for registrants ages twenty-six through twenty-nine who are found to be "necessary to and regularly engaged in" activities in war production or in support of the national health, safety, or interest is that they will remain in civilian life for the time being, subject to adjustment as the needs of the armed forces change. The prospect for registrants ages thirty through thirty-seven, regardless of their physical condition, and for registrants of any age who are either disqualified for general military service or qualified for limited military service only, and who are "regularly engaged in" and who remain in activities in war production or in support of the national health, safety, or interest is that they will remain in civilian life for an indefinite period, subject to adjustment as the needs of the armed forces change.

Part II
Registrants Ages 18 Through 25

2. Deferment Restriction—No registrant age eighteen through twenty-five (except a registrant described in paragraph three of this part) may be retained or placed in Class II-A or Class II-B unless:

(a) The local board finds that he is "necessary to and regularly engaged in" an activity in war production or in support of the national health, safety or interest; and

(b) There is filed with the local board either:

1. A Form 42-A (Special) upon which the state director of selective service in whose state such registrant's principal place of employment is located has indorsed a recommendation that the local board except the registrant from the general rule prohibiting occupational deferment of registrants ages eighteen through twenty-five. . . .

3. Deferment of registrants disqualified for military service or qualified for limited military service only—A registrant, age eighteen through twenty-five found to be disqualified for any military service or found to be qualified for limited military service only may be retained or placed in Class II-A if he is "regularly engaged in" an activity in support of the national health, safety or interest, or in Class II-B if he is "regularly engaged in" an activity in war production.

4. Reopening and classification new—The classification of a registrant, age eighteen through twenty-five, who is in a class available for service shall be reopened and he shall be classified anew if at any time before his induction the local board receives a Form 42 (special) or a Form 42-A (special) executed in the manner required by this memorandum.

Part III
Registrants Ages 26 Through 29

A registrant age twenty-six through twenty-nine may be retained or placed in Class II-A if he is found to be "necessary to and regularly engaged in" an activity in support of the national health, safety, or interest, or in Class II-B if he is found to be "necessary to and regularly engaged in" an activity in war production.

3. Registrant disqualified for military service or qualified for limited military service only.—A registrant age twenty-six through twenty-nine found to be disqualified for any military service or found to be qualified for limited military service only may be retained or placed in Class II-A if he is "regularly engaged in" an activity in support of the national health, safety, or interest, or in Class II-B if he is "regularly engaged in" an activity in war production.

4. Review and reclassification anew.—The classification of a registrant age twenty-six through twenty-nine who is in a class available for service shall be reviewed, and if the local board determines that, under the provisions of this part, he may be qualified for classification in either Class II-A or Class II-B, it shall reopen his classification and classify him anew.

5. Consideration of fathers.—Fathers ages twenty-six through twenty-nine, if other factors are equal, will normally be accorded occupational deferment in preference to non-fathers in this age group.

Part IV
Registrants Ages 30 Through 37

1. General Rule—A registrant age thirty through thirty-seven (whether or not he has been found disqualified for any military service or qualified for limited military service only) shall be retained or placed in Class II-A if he is "regularly engaged in" an activity in support of the national health, safety, or interest; or in Class II-B if he is "regularly engaged in" an activity in war production.

2. Review and Classification Anew—As a result of previous policies based upon manpower requirements of the armed forces, a substantial number of registrants ages thirty through thirty-seven have been placed in Class I-A, class I-A-O or Class IV-E who will now qualify for deferment in Class II-A or Class II-B under the provisions of this memorandum. In order to eliminate avoidable uncertainty on the part of registrants and employers, the classification of every registrant age thirty through thirty-seven who is in a class available for service shall be reviewed, and if the local board determines that he is "regularly engaged in" an activity in war production or in support of the national health, safety, or interest, it shall reopen his classification and classify him anew (Form 42B may be used for making requests for the occupational deferment of registrants in this age group).

Part V
Registrants Ages 38 Through 44

General—Registrants ages thirty-eight through forty-four are not currently acceptable for induction by the armed forces. There is no urgent need for the classification or reclassification of such registrants at this time.

Water Conservation and Population Shift

THE demand on water works systems by new consumers in hundreds of communities of the United States since Pearl Harbor, is graphically illustrated in a news release (NB–2368) from the Office of War Information on April 19, 1944. This news story refers to the great shift in civilian population during the past 3½ yr. For water works men it tells a second story: the importance of the wise use of water in the over-populated centers, and the need for careful planning of plant extensions and service extensions during the period of the war.

In 1940 the U.S. population distribution figures were laboriously gathered by the Bureau of Census. In less than 3½ yr. those figures have become as scrambled as Humpty-Dumpty after his illustrious fall. This shift can be attributed to the migration of war workers, according to the OWI news release, which is based on information furnished by the Bureau of Census, War Manpower Commission, National Selective Service Headquarters and the WPB.

The estimates of this shift were made up from registrations for the War Ration Book Four, and show that between April 1940 and November 1943, the increase in the population of 152 counties of the U.S. was 15 per cent or more, while 469 communities reported increases in population. Gain in the 469 counties was 4,857,885 persons, and this figure is the minimum migration, according to the Bureau of Census. In addition to this, uncounted numbers of persons have changed locations several times.

Greatest gain in population was in those counties which have war plants, or military establishments. Growth was more rapid in metropolitan centers, indicating a trend from rural to city areas.

Horace Greeley's advice to "go West," has become more than an historical remark to aspiring young men. Both young men and young women have rushed into war production centers by the hundreds of thousands, and in particular they have turned their steps westward. The national trend has been most evident away from the Northeast Atlantic states and into the West Coast states. New York alone lost 1,001,238. The U.S. Pacific Coast states of Washington, Oregon and California gained 1,013,629, or 13.3 per cent. The entire mid-west, particularly those sections where industrial activity is limited, suffered loss of workers. In Buffalo approximately 1,500 workers a month are reported to have left in recent months, and in Baltimore, an area of intense industrial activity, several thousand workers are needed at present to fill current demands.

WMC is conducting an intensive re-

cruiting campaign throughout Region IV (Maryland, Virginia, West Virginia, North Carolina and the Dist. of Columbia) to obtain 300,000 workers for essential industries. About 60,000 of these are to be recruited, if possible, from areas of less stringent demand in the region by means of United States Employment Service facilities and mobile recruiting units. They will constitute "In-migrants" into stringent areas. The balance is to be obtained from local sources and transfers from less essential jobs.

Detroit, which is the number one war production area in terms of war contracts, has experienced a leveling off of in-migrations, but out-migrations are increasing, though not to the extent that they exceed the number of persons coming into the area.

War activity has been on the increase in Chicago for many months, although at the beginning of the war the reverse was the case, many Chicago workers having migrated to other parts of the country where production was expanding rapidly. Now almost all unemployed in the Chicago area have been absorbed and workers have been asked to switch from less essential to war jobs. Late in 1943, the manpower situation became so critical in certain sections of Chicago that South Chicago was classified as Group I area (area of acute labor shortage), and in February of this year, the situation in the Chicago region having become critical, it was declared a Group I area. The increased stringency of manpower has opened up opportunities for all local, as well as migrant workers.

War activity in New York has gradually increased, and at present the city is fifth in the nation's metropolitan areas in total war contracts.

Counties in the U.S. showing the greatest per cent of increase are listed in Table I. A reference to this list shows that Detroit gained over 258,000 persons; Los Angeles around 378,000; San Diego, California, over 118,000,

The foregoing will remind water works men of the remarks made by A. W. Gorman at the California Section meeting last fall (Jour. A.W.W.A., **36**: 32 (1943)):

"The impact of this war on the West Coast has been heavy and there are positive indications that it will increase in intensity. This is reason why all of us who are concerned with water service should have a clear understanding of our responsibilities to the nation and to our consumers."

Mr. Gorman's remarks apply to all sections of the country where populations have increased because of war activities.

Quoting from the book *Water Conservation,** which is filled with information relative to the wise use of water during the war emergency: "The responsibility of water service utilities is greater in wartime than in peacetime. The local water utility must supply war industries with around-the-clock water service for manufacturer, for drinking and for sanitary purposes, and it must cope with possible sabotage through fire. Yet it is becoming more difficult to find trained water works personnel.

"Pipelines that carry water into the distribution systems are made of steel or cast iron . . . battleships, submarine, PT boats, merchant ships, guns and hundreds of needed war weapons are made from these and other materials used by water works

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plants. Your water utility cannot rob war industries engaged in making war materials, and request these materials for its distribution systems, or for pumping plants; even if the utility was unpatriotic enough to attempt to replace or add equipment.

". . . Water plants throughout the Nation are joining in a drive to stop the waste of water; asking customers to repair leaky services and fixtures. . . . No one is asked to curtail water that is actually needed. It's the waste that should be curbed."

Meanwhile the population figures so carefully assembled for the last census have pretty well gone by the board. Judging from what happened after the last war, however, thousands of workers may be expected to remain where they are, taking their chances on employment. Once settled, they don't like to pull up roots again; they may like the new location and the type of work they are doing. In any case, the final effect of wartime and postwar moves will be a general re-sorting of population that will leave its marks on the country for many years. The 1940 census figures will be of little use to anyone as a guide to the population distribution during these hectic years.

TABLE I

List of Counties Showing Rates of Increase (10 Per Cent and Over) in Civilian Population April 1940–November 1943

Chief City	*County*	*State*	*% Increase*
	Mineral	Nev.	572.4
Independence	Inyo	Calif.	122.7
*Las Vegas	Clark	Nev.	122.4
*Panama City	Bay	Fla.	116.6
Dumas	Moore	Tex.	116.1
Prosser	Benton	Wash.	102.9
Twin Falls	Jerome	Idaho	93.1
*Brunswick	Glynn	Ga.	91.1
*Pascagoula	Jackson	Miss.	85.1
Cody	Park	Wyo.	83.5
Robbinsville	Graham	N. C.	81.9
Yuma	Yuma	Ariz.	81.0
Tahoka	Lynn	Tex.	73.8
Levelland	Hockley	Tex.	71.1
Wilmington	New Hanover	N. C.	65.0
Fillmore	Millard	Utah	64.3
Alturas	Modoc	Calif.	63.7
*Mobile	Mobile	Ala.	60.9
Norfolk (Va.) Area			57.1
	Warwick	Va.	198.7
*Elizabeth City, Hampton City		Va.	99.9
*Norfolk City, Portsmouth City, South Norfolk City		Va.	50.8
*Newport News City		Va.	42.8
	Princess Anne	Va.	30.7
*San Diego	San Diego	Calif.	42.9
*Charleston	Charleston	S. C.	37.5
*Wichita	Sedgwick	Kan.	36.0
Savannah	Chatham	Ga.	28.9

TABLE I—*Continued*

Chief City	*County*	*State*	*% Increase*
Washington, (D. C.) Area			27.8
	Arlington	Va.	54.6
Alexandria City		Va.	53.8
	Fairfax	Va.	39.2
	Prince Georges	Md.	31.9
*Washington City		D. C.	24.2
	Montgomery	Md.	24.1
San Francisco (Calif.) Area			26.0
	Contra Costa	Calif.	117.7
	Solano	Calif.	102.8
	Marin	Calif.	44.5
	San Mateo	Calif.	22.2
	Alameda	Calif.	21.3
Portland (Ore.) Area			24.0
*Vancouver	Clark	Wash.	98.3
	Multnomah	Ore.	26.2
Beaumont (Tex.) Area			22.7
	Orange	Tex.	163.3
	*Jefferson	Tex.	22.7
Corpus Christi	Nueces	Tex.	22.4
Columbus (Ga.) Area			22.2
	*Muscogee	Ga.	28.9
Columbus City		Ga.	22.2
*Macon	Bibb	Ga.	21.5
*Tacoma	Pierce	Wash.	20.6
Fort Worth	Tarrant	Tex.	18.8
Galveston (Tex.) Area			18.2
	Brazoria	Tex.	71.8
*Galveston City		Tex.	18.2
Seattle (Wash.) Area			18.2
*Bremerton, Port Orchard	Kitsap	Wash.	113.1
	*King	Wash.	18.2
Jacksonville	Duval	Fla.	16.6
San Antonio	Bexar	Tex.	15.3
Charleston	Kanawha	West Va.	14.7
Dayton (Ohio) Area			14.6
	Greene	Ohio	25.1
	Montgomery	Ohio	14.6
Evansville (Ind.) Area			14.1
	Vanderburgh	Ind.	15.7
Houston	Harris	Tex.	13.7
*Stockton	San Joaquin	Calif.	13.1
Los Angeles (Calif.) Area			13.0
	Orange	Calif.	17.2
	Los Angeles	Calif.	12.8
Louisville	Jefferson	Ky.	12.7
Baltimore (Md.) Area			12.5
	Baltimore	Md.	30.8
	Anne Arundel	Md.	25.5
*Baltimore City		Md.	8.3
Columbus	Richland	S. C.	11.8
San Jose	Santa Clara	Calif.	11.3
Dallas	Dallas	Tex.	11.2
Tampa-St. Petersburg	Hillsborough Pinellas	Fla.	10.8

TABLE I—*Continued*

Chief City	*County*	*State*	*% Increase*
Sacramento	Sacramento	Calif.	10.8
Phoenix	Maricopa	Ariz.	10.7
Tulsa	Tulsa	Okla.	10.3
**Detroit (Mich.) Area*			10.0
	Macomb	Mich.	32.2
	Oakland	Mich.	17.0
	Wayne	Mich.	8.0
Miami	Dade	Fla.	10.0

* Group I labor shortage areas as of March 1, 1944.
* Source—Bureau of the Census.

Water Supply in Congested War Production Areas *

Established to aid the Federal agencies and local and state governments in providing community facilities in war-congested production areas, the Committee for Congested Production Areas in its first year of service just ended, has worked in eighteen acute labor sections of the country, with satisfactory results.

Among the fundamental needs at the time the Committee began its work were housing, water supply, sewage disposal and allied facilities for production areas. The following table relating to water supplies as of May 1, 1944, has been made up from information released by the Committee. It should prove interesting to water works men:

Adequacy and Trend of Community Water Supplies in Certain Designated Congested Areas—May 1, 1944

Area	*Water Supply*	*Status*
Puget Sound (Wash.)	Adequate	Improved
Portland (Ore.) Vancouver (Wash.)	Adequate	Unchanged
San Francisco Bay (Calif.)	Fair	Unchanged
Los Angeles (Calif.)	Adequate	Unchanged
San Diego (Calif.)	Inadequate	Unchanged
Detroit-Willow Run (Mich.)	Fair	Improved
Beaumont-Orange (Tex.)	Fair	Improved
Mobile (Ala.)	Inadequate	Improved
Key West (Fla.)	Inadequate	Worse
Charleston (S. C.)	Fair	Improved
Hampton Roads (Va.)	Fair	Improved

In publishing this information the A.W.W.A. neither approves nor takes issue with the data released by the Committee for Congested Production Areas.